Product Service

TEST REPORT

Standard DIN VDE 0126-1-1 (VDE V 0126-1-1):2013

TÜV SÜD Test Report for Automatic disconnection device between a generator and the public low-voltage grid

Report reference No. :	70.409.14.130.01-00
Date of issue :	2014-10-23
Project handler :	Kai Zhao
TÜV SÜD Branch :	TÜV SÜD Certification and Testing (China) Co., Ltd. Shanghai Branch
Address :	No. 88 Heng Tong Road 200070 Shanghai P.R. CHINA
Testing location :	Nanjing CQC - Trusted Testing Technology Co., Ltd. No.99,Wenlan Road, Xianlin University Zone, Xianlin Street, Qixia District, NanJing, China
Client :	JIANGSU GOODWE POWER SUPPLYTECHNOLOGY CO., LTD.
Client number :	N/A
Address :	No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, PEOPLE'S REPUBLIC OF CHINA
Contact person :	Mrs. Xie Jing
Standard :	This TUV SUD test report form is based on the following requirements: DIN VDE 0126-1-1 (VDE V 0126-1-1):2013
TRF originated by :	TÜV SÜD Certification and Testing (China) Co., Ltd., Mr. Frank Zhu
Copyright blank test report :	This test report is based on the content of the standard (see above). The test report considered selected clauses of the a.m. standard(s) and experience gained with product testing. It was prepared by TUV SUD Product Service GmbH. TUV SUD Group takes no responsibility for and will not assume liability for damages resulting from the reader's interpretation of the reproduced material due to its placement and context.
Test procedure :	☐ GS ☒ TÜV Mark, ☐ EU-Directive, ☐ without certification ☐ type verification of comformity
Non-standard test method :	N/A
National deviations :	N/A
Number of pages (Report) :	99
Number of pages (Attachments) :	See page 3 for detail
Compiled by : *Kai Zhao*	Approved by : *Pengdong Yang*
(+ signature)	(+ signature)

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Test sample……..:	Engineering prototype
Type of test object ..... :	PV Grid-connected Inverter
Trademark ..... :	GOODWE your solar engine
Model and/or type reference ..... :	GW10K-DT, GW12K-DT, GW15K-DT, GW17K-DT, GW20K-DT, GW25K-DT
Rating(s) ..... :	PV input: Vmax PV: 1000 Vdc; MPP voltage range: 260 … 850 Vdc Rated DC voltage: 640 Vdc Max. DC current: 22/11 Adc (GW10K-DT, GW12K-DT) 22/22 Adc (GW15K-DT, GW17K-DT, GW20K-DT) 27/27 Adc (GW25K-DT) Isc PV: 27/20 Adc (GW10K-DT, GW12K-DT) 27/27 Adc (GW15K-DT, GW17K-DT, GW20K-DT) 32/32 Adc (GW25K-DT) AC output: Rated grid voltage: 3/N/PE ~ 400/230V Rated grid frequency: 50Hz Max. output current: 17 Aac (GW10K-DT), 19 Aac (GW12K-DT), 25 Aac (GW15K-DT, GW17K-DT), 30 Aac (GW20K-DT), 37 Aac (GW25K-DT) Rated AC power: 10 kW (GW10K-DT), 12 kW (GW12K-DT), 15 kW (GW15K-DT), 17 kW (GW17K-DT), 20 kW (GW20K-DT), 25 kW (GW25K-DT) Power factor range: 1@nominal power(adj: 0,9cap…0,9ind) Operating temperature range: -25 … +60°C
Manufacturer ..... :	JIANGSU GOODWE POWER SUPPLYTECHNOLOGY CO., LTD.
Manufacturer number… ..... :	N/A
Address ..... :	No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, PEOPLE'S REPUBLIC OF CHINA
Sub-contractors/ tests (clause) ..... :	N/A
Name ..... :	N/A
Order description… ..... :	☒ Complete test according to TRF ☐ Partial test according to manufacturer's specifications ☐ Preliminary test ☐ Spot check
Date of order…… ..... :	2014-08-21
Date of receipt of test item ..... :	2014-08-21
Date(s) of performance of test ..... :	2014-08-23 – 2014-10-03

Test item particulars:

All the tests results confirmed to the requirements of the standard.

Attachments:

This test report comprises 99 pages which shall be used in conjunction with the following test reports:

Test report #	Description	Pages
1	IEC/EN 62109-1:2010 test report	96
2	IEC/EN 62109-2:2011 test report together with equipments list	39
3	VDE-AR-N 4105: 2011 and DIN VDE V 0124-100(VDE V 0124-100):2012 test report	147
4	Data form for electrical and electronic component(CDF)	22
5	Functional safety technical report	81

General remarks:

"(see remark #)" refers to a remark appended to the report.
"(see appended table)" refers to a table appended to the report.
Throughout this report a comma is used as the decimal separator.
The test results presented in this report relate only to the object tested.
This report shall not be reproduced except in full without the written approval of the testing laboratory.

Summary of testing:

☐ deviation(s) found

☒ no deviations found

Individual inverter assessed based on component basis,

Test items below according to DIN VDE 0126-1-1 (VDE V 0126-1-1), all tests were conducted on GW25K-DT

☒ 4.1&6.1 Functional safety, DIN VDE 0126-1-1 (VDE V 0126-1-1)

☒ 4.2 Connection condition, DIN VDE 0126-1-1(VDE V 0126-1-1)

☒ 4.3&6.2&6.3 Voltage monitoring, DIN VDE 0126-1-1(VDE V 0126-1-1)

☒ 4.4&6.4 Frequency monitoring, DIN VDE 0126-1-1(VDE V 0126-1-1)

☒ 4.5&6.5 DC current monitoring, DIN VDE 0126-1-1(VDE V 0126-1-1)

☒ 4.6&6.6 Detection of islanding operation, DIN VDE 0126-1-1(VDE V 0126-1-1)

☒ 4.8 Requirement for the integrated disconnection device in photovoltaic converter - residual current monitoring and for the isolation monitoring, DIN VDE 0126-1-1(VDE V 0126-1-1) & IEC/EN 62109-2

Product Service

Copy of marking plate:

GOODWE
your solar engine

TYPE:GW10K-DT

Max. PV-generator power	10200W
PV-voltage range	250 ... 1000$V_{d.c.}$
Vmax PV	1000$V_{d.c.}$
Isc PV	27/20$A_{d.c.}$
Rated DC voltage	640$V_{d.c.}$
MPPT voltage range	260 ... 850$V_{d.c.}$
Max. DC current	22/11$A_{d.c.}$
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	17$A_{a.c.}$
AC-grid frequency	50Hz
Rated AC power	10kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1; MEA&PEA;
En50438; G59/3; NRS097-2-1; AS4777.2/.3;
ERDF-NOI-RES_13E;

5min

SAA 121612

G59

S/N:

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GOODWE
your solar engine

TYPE:GW12K-DT

Max. PV-generator power	12300W
PV-voltage range	250 ... 1000$V_{d.c.}$
Vmax PV	1000$V_{d.c.}$
Isc PV	27/20$A_{d.c.}$
Rated DC voltage	640$V_{d.c.}$
MPPT voltage range	260 ... 850$V_{d.c.}$
Max. DC current	22/11$A_{d.c.}$
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	19$A_{a.c.}$
AC-grid frequency	50Hz
Rated AC power	12kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1;
En50438; AS4777.2/.3; G59/3; NRS097-2-1;
ERDF-NOI-RES_13E;

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Product Service

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TYPE:GW15K-DT

Max. PV-generator power	15400W
PV-voltage range	250 ... 1000$V_{d.c.}$
Vmax PV	1000$V_{d.c.}$
Isc PV	27/27$A_{d.c.}$
Rated DC voltage	640$V_{d.c.}$
MPPT voltage range	260 ... 850$V_{d.c.}$
Max. DC current	22/22$A_{d.c.}$
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	25$A_{a.c.}$
AC-grid frequency	50Hz
Rated AC power	15kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1;
En50438; AS4777.2/.3; G59/3; NRS097-2-1;
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GOODWE
your solar engine

TYPE:GW17K-DT

Max. PV-generator power	17500W
PV-voltage range	250 ... 1000$V_{d.c.}$
Vmax PV	1000$V_{d.c.}$
Isc PV	27/27$A_{d.c.}$
Rated DC voltage	640$V_{d.c.}$
MPPT voltage range	260 ... 850$V_{d.c.}$
Max. DC current	22/22$A_{d.c.}$
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	25$A_{a.c.}$
AC-grid frequency	50Hz
Rated AC power	17kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1;
EN50438; AS4777.2/.3; G59/3; NRS097-2-1;
ERDF-NOI-RES_13E;

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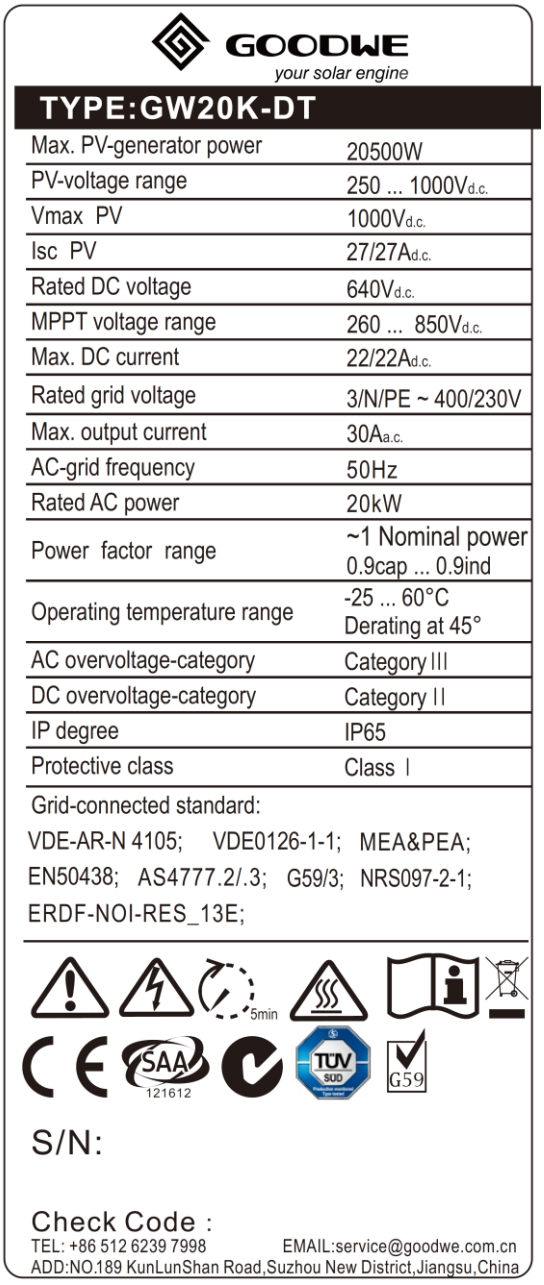

GOODWE
your solar engine

TYPE:GW20K-DT

Max. PV-generator power	20500W
PV-voltage range	250 ... 1000Vd.c.
Vmax PV	1000Vd.c.
Isc PV	27/27Ad.c.
Rated DC voltage	640Vd.c.
MPPT voltage range	260 ... 850Vd.c.
Max. DC current	22/22Ad.c.
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	30Aa.c.
AC-grid frequency	50Hz
Rated AC power	20kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105; VDE0126-1-1; MEA&PEA;
EN50438; AS4777.2/.3; G59/3; NRS097-2-1;
ERDF-NOI-RES_13E;

5min SAA 121612 G59

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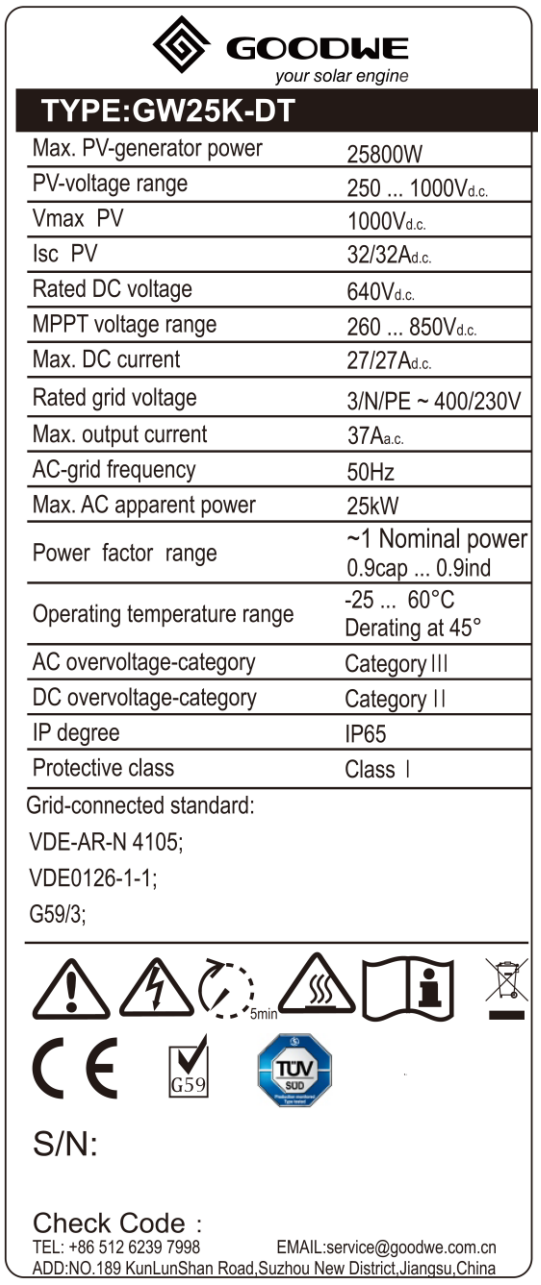

GOODWE
your solar engine

TYPE:GW25K-DT

Max. PV-generator power	25800W
PV-voltage range	250 ... 1000Vd.c.
Vmax PV	1000Vd.c.
Isc PV	32/32Ad.c.
Rated DC voltage	640Vd.c.
MPPT voltage range	260 ... 850Vd.c.
Max. DC current	27/27Ad.c.
Rated grid voltage	3/N/PE ~ 400/230V
Max. output current	37Aa.c.
AC-grid frequency	50Hz
Max. AC apparent power	25kW
Power factor range	~1 Nominal power 0.9cap ... 0.9ind
Operating temperature range	-25 ... 60°C Derating at 45°
AC overvoltage-category	Category III
DC overvoltage-category	Category II
IP degree	IP65
Protective class	Class I

Grid-connected standard:
VDE-AR-N 4105;
VDE0126-1-1;
G59/3;

5min G59

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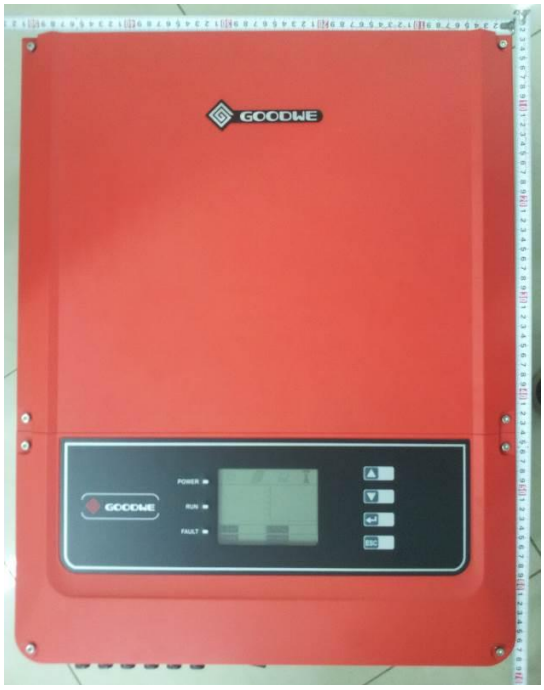
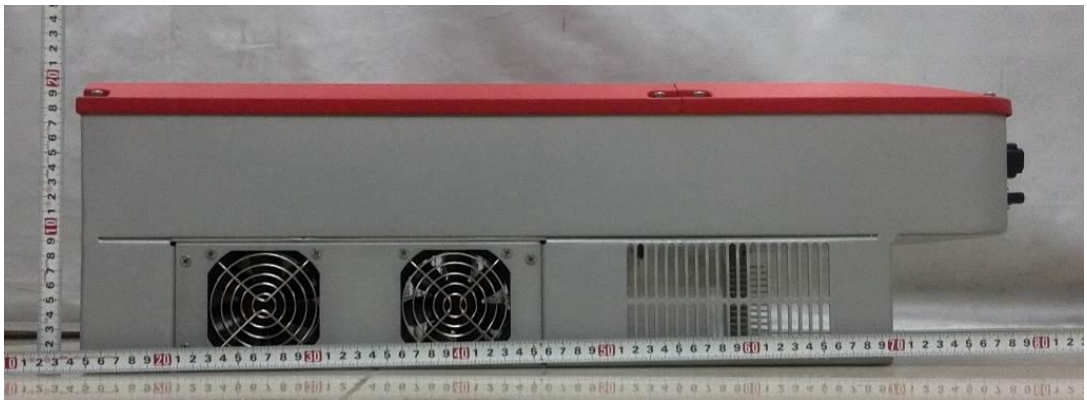
Marking plate material: pressure-sensitive unprinted label stocks stamped into aluminium surface; Suitable for outdoor use with respect to exposure to Ultraviolet Light, Water Exposure and thermal transfer printed label stock applications, -60°C to 95°C

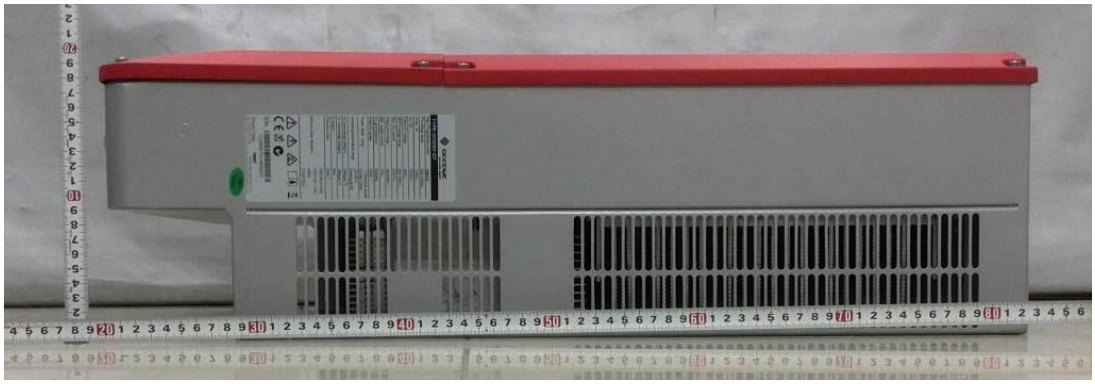
An additional PET film provided to cover label.

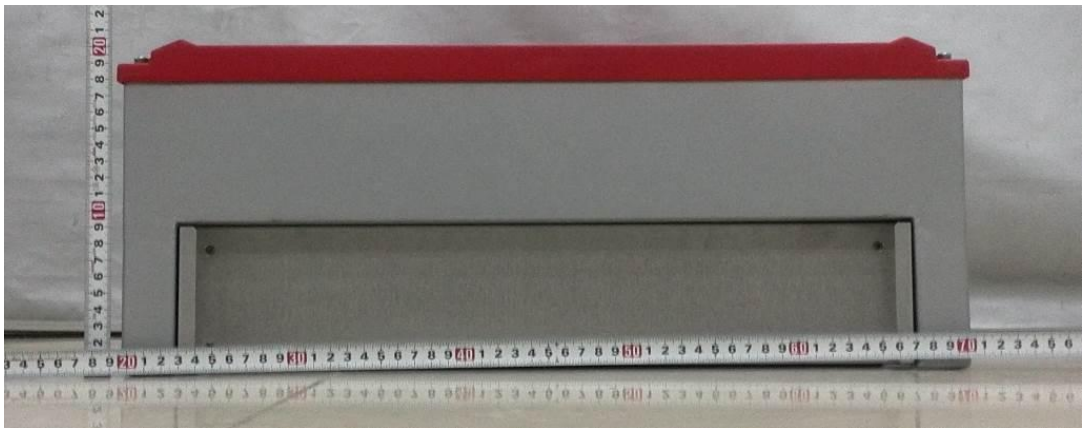
Picture of the product

Basic model: GW25K-DT, major difference between individual model refer to “Purpose of the product”









Characteristic data

Product Service

6.1 Technical Parameters

Model	GW09K-DT	GW10K-DT	GW12K-DT	GW15K-DT	GW17K-DT	GW20K-DT	GW25K-DT
DC input Data							
*Max. DC power(W)	9200	10200	12300	15400	17500	20500	25800
Max. DC voltage (V)	1000	1000	1000	1000	1000	1000	1000
MPPT voltage range (V)	260~850	260~850	260~850	260~850	260~850	260~850	260~850
Starting voltage (V)	250	250	250	250	250	250	250
Max. DC current (A)	22/11	22/11	22/11	22/22	22/22	22/22	27/27
DC overcurrent protection(A)	33	33	33	33	33	33	38
No. of DC connectors	4	4	4	6	6	6	6
No. of MPPTs	2	2	2	2 (can parallel)			
DC overvoltage category	Category II						
DC connector	SUNCLIX / MC4 (optional)						
AC Output Data							
Norminal AC power(W)	9000	10000	12000	15000	17000	20000	25000
Max. AC power(W)	9000	10000	12000	15000	17000	20000	25000
Max. AC current(A)	15	17	19	25	25	30	37
AC overcurrent protection(A)	42	42	42	54	54	60	72
Norminal AC output	50/60Hz; 400Vac						
AC output range	45~55Hz/55~65Hz; 310~480Vac						
THDi	<1.5%						
Power factor	0.9 leading~0.9 lagging						
Grid connection	3W/N/PE						
AC overvoltage category	Category III						
Efficiency							
Max. efficiency							
Euro efficiency	98.0%	98.0%	98.0%	98.2%	98.2%	98.2%	98.2%
MPPT adaptation efficiency	>97.5%	>97.5%	>97.5%	>97.5%	>97.5%	>97.5%	>97.5%
Protection	>99.5%	>99.5%	>99.5%	>99.5%	>99.5%	>99.5%	>99.5%
Residual current monitoring unit	Integrated						
Anti-islanding protection	Integrated						
DC switch	Integrated (optional)						
AC over current protection	Integrated						
Insulation monitoring	Integrated						
Certifications&Standards							
Grid regulation	VDE0126-1-1 ERDF-NOI-RES_13E	VDE-AR-N 4105 G59/3, EN50438 NRS097-2-1 AS4777.2&.3 VDE0126-1-1 IEC62109-2 MEA, PEA, RD1699 ERDF-NOI-RES_13E	VDE-AR-N 4105, G59/3, NRS097-2-1 AS4777.2&.3, IEC62109-2 VDE0126-1-1, RD1699, EN50438 ERDF-NOI-RES_13E		G59/3, EN50438 AS4777.2&.3 VDE0126-1-1 NRS097-2-1 IEC62109-2 MEA, PEA, RD1699 ERDF-NOI-RES_13E		VDE-AR-N 4105 VDE0126-1-1 G59/3

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Product Service

Model	GW09K-DT	GW10K-DT	GW12K-DT	GW15K-DT	GW17K-DT	GW20K-DT	GW25K-DT
Safety	IEC62109-1&-2, AS3100						
EMC	EN 61000-6-1,EN 61000-6-2,EN 61000-6-3,EN 61000-6-4, EN 61000-3-11, EN 61000-3-12						
General Data							
Dimensions (WxHxD)	516*650*203mm						
Weight (kg)	39	39	39	39	39	39	41
Mounting	Wall bracket						
Ambient temperature range	-25~60°C (>45°C derating)						
Relative humidity	0~95%						
Moisture location category	4K4H						
Max. operating altitude	2000m						
Protection degree	IP65						
Environment category	Outdoor & indoor						
External environment pollution degree	Grade1、2、3						
Topology	Transformerless						
Night power consumption(W)	<1						
Cooling	Natural Convection						
Noise emision(dB)	<45						
Display	5.0'' LCD						
Communication	USB2.0; RS485 or WiFi						
Standard warranty(years)	5/10/15/20/25 (optional)						

Characteristic data Factory

JIANGSU GOODWE POWER SUPPLYTECHNOLOGY CO., LTD.

No. 189 Kun Lun Shan Road, Suzhou New District, 215163 Suzhou, Jiangsu, PEOPLE'S REPUBLIC OF CHINA

Purpose of the product

These devices are transformer-less grid-connected PV inverters which converts direct current optimized by photovoltaic DC conditioner to alternating current, and it is intended to be connected in parallel with the low-voltage mains to supply common load.
They are intended for professional incorporation into PV system, and they are assessed on a component test basis.
GW25K-DT: basic model
GW20K-DT: technical similar as basic model, except for type name and parameters, refer to rating label
GW17K-DT: technical similar as basic model, except for type name and parameters, refer to rating label
GW15K-DT: technical similar as basic model, except for type name and parameters, refer to rating label
GW12K-DT: technical similar as basic model, except for type name and parameters, refer to rating label
GW10K-DT: technical similar as basic model, except for type name and parameters, refer to rating label
For different components, refer to below table

Reference Position	GW10K-DT	GW12K-DT	GW15K-DT	GW17K-DT	GW20K-DT	GW25K-DT	Comment
LR, LS, LT	141-10012	141-10012	141-10011	141-10011	141-10011	141-10035	Inverter Choke
Boost	141-10012	141-10012	141-10012	141-10012	141-10012	141-10034	Boost

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Choke							Choke
Bus Cap	800V/50uF(6pcs)	800V/50uF(8pcs)	800V/50uF(10pcs)	800V/50uF(12pcs)	800V/50uF(12pcs)	800V/50uF(14pcs)	Inverter Bus Capacitor
RY400, RY401, RY402, RY403, RY406, RY407	180-00004	180-00004	180-00004	180-00004	180-00004	180-00017 180-00016	Relay
L100,L101	141-18001	141-18001	141-18001	141-18001	141-18001	NC	Resonant choke
Q103,Q107	1200V/40A	1200V/40A	1200V/40A	1200V/40A	1200V/40A	NC	IGBT
D103,D104,D113,D114	1200V/30A	1200V/30A	1200V/30A	1200V/30A	1200V/30A	NC	Diode
Input Filter Cap	390uF/500V(4pcs)	390uF/500V(4pcs)	390uF/500V(4pcs)	390uF/500V(4pcs)	390uF/500V(4pcs)	390uF/500V(4pcs) or 40uF/1100V(2pcs)	Input Filter Cap
R551	NC	NC	NC	NC	2.49 kW	2.49 kW	Model Identify Resistor
R552	10 kW	10 kW	10 kW	10 kW	NC	10 kW	
R555	NC	NC	NC	NC	NC	NC	
R556	10 kW	10 kW	10 kW	10 kW	10 kW	10 kW	
R545	NC	5.6kW	NC	5.6 kW	NC	5.6 kW	
R546	10 kW	10 kW	10 kW	10 kW	10 kW	10 kW	
R547	NC	NC	5.6kW	5.6 kW	NC	NC	
R548	10 kW	10 kW	10 kW	10 kW	10 kW	10 kW	
Q100, Q101	1200V/40A	1200V/40A	1200V/40A	1200V/40A	1200V/40A	1200V/40A	Boost Main MOSFET
Q105, Q106	1200V/25A	1200V/25A	1200V/40A	1200V/40A	1200V/40A	1200V/40A	Boost Main MOSFET
D112	NC	NC	1200V/75A	1200V/75A	1200V/75A	1200V/18A (in parallel)	Clamping Diode
R446, R508, R536	620W	620W	200W	200W	150W	100W	Inverter current sampling resistor
PV input connector in parallel	4	4	6	6	6	6	Number of input connector groups
AC Common choke	141-11005	141-11005	141-11005	141-11005	141-11005	141-11007	AC Common Choke
External	2/1	2/1	2	2	2	2	Total

DC fan	optional	optional					number
Inverter Module	1200V/40 A	1200V/40 A	1200V/80 A	1200V/80 A	1200V/80 A	1200V/80 A	Inverter Module
	1200V/80 A	1200V/80 A	600V 50A	600V 50A	600V 50A	600V 50A	
	600V 50A	600V 50A	-	-	-	-	
	Remark: NC= not connected						

The components DC switch is optional for all models, with or without it, see specification and user manual. An external isolating mean should be provided on the DC side if inverter without integrated DC switch, but the parameter of DC switch should not be degraded. The opening of DC switch position on enclosure is sealed for the inverter without DC switch. There are two AC connector brands for inverter, VACONN Series and Waterproof Coupling Series.
Firmware version: V1.06.08
The following documentations are retained on file:
- Photograph;
- Circuit diagrams;
- PCB layout drawing;
- PCB foil pattern assembly drawing;
- Specification sheets for components;
- Instruction manual.
- Manufacturer's work instruction and declaration for 100% routing test as required by IEC/EN 62109-1:2010, IEC/EN62109-2:2011, DIN VDE 0126-1-1(VDE V 0126-1-1):2013.

Conditions of acceptability---

1. When installing the equipment, all requirements of the mentioned standards must be fulfilled.

2. In order to protect the installation against electrical and fire hazard, all branch circuits in an installation, switchgear, cables etc., must be short-circuit and over-current protected according to the national/international regulations.

3. When install PV generation system, double/reinforced insulation cable required with mechanical protection.
Recommended conductor cross-section area and installation method, refer to installation manual:
Recommended PV input cables: copper, PV+&PV-, 2,5 mm² - 4 mm²@Max. 60°C ambient temperature.
Recommended AC output cables: copper, L1, L2, L3, N, PE, cross-section refer to below table

Model	GW10K-DT	GW12K-DT	GW15K-DT	GW17K-DT	GW20K-DT	GW25K-DT
cross-section(mm^2)	4-10	4-10	4-10	4-10	6-10	6-10

All type of PV inverters with operating time of the type C circuit breaker or fuse is less than 5 seconds, wire installation method B2 according to EN 60204-1:2006, annex D: cable in conduit cable trunking system. Maybe use H07RN-F (cord designation 60245 IEC 66) for an ambient temperature of up to 40°C or less and use 90°C rough cable for ambient temperature between 40°C and 60°C. If any higher temperature environment used or for decrease the power loss in wire runway, it shall increase the conductor current carrying capacity and recalculation.

4. Maximum inverter backfeed current form grid to the array is 0A based on test/circuit topology analysis and manufacturer's declaration. And due to design, more than three strings can be connected to inverter, so backfeed current can form others strings to the fault string when short-circuit occurs, PV fuse need to be installed in end-system according to system requirement based on solar irradiation, local temperature and environment, e.g. ratings 1000V, 1.5Isc.

5. Serial – RS485 are used for telecommunication interface ports with circuitry intended for connection to a Network Environment 0 per manufacturer's instruction manual, according to IEC TR 62102.

RS 485 circuit is classed to be as SELV, Only PELV or SELV voltages may be connected at RS 485 terminals.

6. The inverter is intended to be used with appropriate PV-generator, switchgear, SPDs, combiner feeder box, distribution board, electrical protection components and other device to form complete end systems.

Compliance with safety regulations depends upon installing and configuring inverter correctly, including using the specified emergency stop device adjacent to solar inverter. The unit must be installed only by professional assemblers who are familiar with requirements for safety and EMC. The assembler is responsible for ensuring that the end product or system complies with all the relevant laws in the country where it is to be used. Refer to instruction manual.

7. Additional equipment connected to the inverter must comply with the respective IEC, EN or ISO standards (e.g. IEC/EN 60950 for data processing equipment, IEC/EN 61439 for switchgear).

8. To allow maintenance of PV inverter, means of isolating the PV inverter from the DC side and the AC side shall be provided at the end-use application.

9. For safety reasons, install the emergency stop devices at station adjacent to solar inverter in the end-system. Pressing the stop function on the control panel of the inverter does generate an emergency stop and separate the inverter from dangerous potential.

10. An additional RCD, type B according to IEC 60755, amendment 2 which is located between the inverter and the mains, may be provided for fault protection by automatic disconnection of supply in the end-use application with the agreement of local network operator.

11. Island operation can be detected independently for individual unit. For multiple units operation, the automatic disconnection device should receive break commands via an interface from another protection device with equivalent island network detection. A break command must trigger a break within 0.2 s. The protection device issuing the break signal and the interface must also fulfill the functional safety requirements.

12. Not intended for use with connection to plug socket!

13. The following safety parameters are factory set and fixed per IEC/EN 62109-2, VDE-AR-N 4105:2011 and DIN VDE 0126-1-1(VDE V 0126-1-1):2013.

Default interface protection settings

Parameters	Normative requirements		Internal threshold setting	
	Maximum clearance time	Trip limit	Maximum clearance time (factory setting)	Factory setting trip value
Over voltage – state 10 minutes mean value corresponding to EN 50160	200ms	400/230V~ +10%...15%	200ms	9min@440/253V
Over voltage – stage 2	200ms	Phase to neutral : 264,5V~	160ms	Phase to neutral : 264,5V~
	200ms	Phase to Phase: 460V~	160ms	Phase to Phase: 460V~
Under voltage	200ms	Phase to neutral : 184V~	160ms	Phase to neutral: 184V~
	200ms	Phase to Phase: 320V~	160ms	Phase to Phase: 320V~
Over frequency	200ms	51,5Hz	60ms	51,5Hz
Under frequency	200ms	47,5Hz	60ms	47,5Hz
Reconnection voltage range after a network outage and response to abnormal conditions	-	85 % Un to 110 % Un(340/195,5V-440/253V)	-	340/195,5V-433/253V
Reconnection	-	47,5Hz to 50,05Hz	-	47,5Hz-50,05Hz

frequency range after a network outage and response to abnormal conditions				
Automatic reconnection after a network outage and response to abnormal conditions ≥ 3s	≥60s	-	-	60s
Automatic reconnection after a network outage and response to short-term interruption < 3s	>5s	-	-	60s
DC injection current	200ms	1A	140ms	900mA
PV array Insulation resistance measurement before starting operation	-	30kΩ	-	100kΩ
Islanding detection	Max. 5s	Loss of mains	200ms	Loss of mains
Continuous residual current	300ms	300mA	240ms	180mA
Sudde hanges in residual current:	300ms	30mA	120ms	24mA
	150ms	60mA;	80ms	48mA
	40ms	150mA;	20ms	100mA

Alteration of the above settings or full setting range of the interface protection may cause a breach of the type-certificate marking.

Unauthorised access to factory safety parameters setting and software should be prohibited.

A reset to the safety parameters requires retest and verification in conjunction with the end-use system.

Possible test case verdicts:

- test case does not apply to the test object ..... : N(.A.) / not included in the order
- test object does meet the requirement ..... : P(ass)
- test object does not meet the requirement ..... : F(ail)

Possible suffixes to the verdicts:

- suffix for detailed information for the client……..: - C(omment)

- suffix for important information for factory inspection...: - M(anufacturing)

Clause	Requirement – Test	Measuring result – Remark	Verdict
4	**Requirements**		**P**
	The following requirements applied to integrated and separated safety disconnect device.	Integrated safety disconnecting device	P
	The disconnection device must disconnect the generator unit from the grid on the AC side with two switches in series due to:	Inverter does not have internal isolated transformer between the mains and PV circuit, 6 pieces VDE approved solar AC relays used(each two in series) for all current carrying conductors. When the contacts fault applied to one relay contact ot one control circuit for two relays, alarm an error code in display panel when first initial start-up or reconnection, also refer to functional safety technical report.	P
	- Voltage-and/or frequency change of low voltage network,		P
	- DC current feed-in into the low voltage network,		P
	- Unintended island operation and		P
	- Intended island operation with standby network generator.		P
4.1	Functional safety	Fulfil with the requirements of single fault condition for the purpose of functional safety concept of this standard together with IEC/EN 62109-1:2010, annex B, programmable equipment and IEC/EN 62109-2:2011	P
	The safety of the functions of automatic disconnection device defined in 4.3 to 4.6 and 4.8, if applicable, shall be ensured under all operation conditions. It can be installed as independent device or integrated parts of generation system and must be disconnect in single fault condition and indicate the fault condition.		P
4.1.1	Single fault safety	Under single fault condition refer to safety function relative circuits, This system allows for: – the safety to always be	P

Clause	Requirement – Test	Measuring result – Remark	Verdict
		maintained in the event of a single fault; – some but not all faults o be detected; – the accumulation of undetected faults to possibly lead to the loss of the safety functions.	
	The disconnection device must fulfill the requirement of single fault safety according to VDE-AR-N 4105: 2011-08, A.6		P
4.1.2	Disconnection device		P
	The disconnection device must comply with DIN EN 62109-2 (VDE 0126-14-2): 2012-04, 4.4.4.15.2 in case of integration in a PV converter and VDE-AR-N 4105: 2011-08, 6.4 in other cases.		P
4.2	Connection condition		P
	The connection, which reconnect after a network fault and reconnect after short interruption, shall comply with VDE-AR-N 4105: 2011-08, 8.3.1.		P
4.3	Voltage monitoring		P
4.3.1	Voltage decrease U<	U<:320/184V	P
	The disconnection due to a voltage decrease must comply with VDE-AR-N 4105: 2011-08, 6.5.1 and 6.5.2		P
4.3.2	Voltage increase U>>	U>>:460/264,5V	P
	The disconnection due to a voltage increase must comply with VDE-AR-N 4105: 2011-08, 6.5.1 and 6.5.2		P
4.3.3	Slow voltage increase U>	U>:440/253V@9min	P
	The disconnection due to a slow voltage increase (10-minute-mean-value) must comply with VDE-AR-N 4105: 2011-08, 6.5.1 and 6.5.2		P
4.4	Frequency monitoring	f>: 51,5Hz; f<: 47,5Hz	P
	The disconnection due to a frequency decrease or a frequency increase must comply with VDE-AR-N 4105: 2011-08, 6.5.1 und 6.5.2		P
4.5	DC current monitoring	140ms@900mA	P
	A DC current feed into the low voltage network due to a disorder system operation must activate the disconnection within 0.2s. For this, the disorder itself or a measured DC component of		P

Clause	Requirement – Test	Measuring result – Remark	Verdict
	current of more than 1A can be regarded as disconnection criterion.		
4.6	Detection of islanding operation	Detection of islanding setting: 200ms, limit: 5s	P
	The disconnection due to the detection of a unintended islanding operation must comply with VDE-AR-N 4105: 2011-08, 6.5.1 and 6.5.3		P
4.7	Marking		P
	A generation with automatic disconnection device must include with visible specification “VDE 0126-1-1”. It can be done through:		P
	- Rating plate or		P
	- Issue on the brochure of disconnection or		N/A
	- A separate labelling		N/A
4.8	Requirement for the integrated disconnection device in photovoltaic converter		P
	The requirement of DIN EN 62109-2 (VDE 0126-14-2): 2012-04, 4.8 for the residual current monitoring and for the isolation monitoring of PV generators must be complied.	See IEC/EN 62109-2 report	P

5	**General requirements**		N/A
	The limits of radio interference shall comply with DIN EN 61000-6-3 (VDE 0839-6-3). The interference immunity are tested according to DIN EN 61000-6-2 (VDE 0839-6-2)	See separated EMC report	N/A

6	**Type test**		P
6.0	General		P
	I If not specified in other cases, the following tests are applied for integrated and separated disconnection device. A separate disconnection device is tested together with a suitable input feeder Here it is to ensure, that the disconnection signal generate not from input feeder but from the disconnection device.		P
6.1	Functional safety		P
	The test on single fault safety and fault detection with followed disconnection shall comply with VDE 0124-100, 5.4.5.2.		P
6.2	Voltage monitoring		P
	The tests of connection are re-connection shall		P

Clause	Requirement – Test	Measuring result – Remark	Verdict
	comply with DIN V DIN VDE V 0124-100 (VDE V 0124-100):2012-07, 5.5.1 and 5.5.2.		
6.3	Voltage monitoring		P
	The test of voltage monitoring shall comply with DIN VDE V 0124-100 (VDE V 0124-100):2012-07, 5.4.5.3		P
6.4	Frequency monitoring		P
	The test of frequency monitoring shall comply with DIN VDE V 0124-100 (VDE V 0124-100):2012-07, 5.4.5.4		P
6.5	DC current monitoring		P
	The test of disconnection due to DC current feed in is done optionally according to a) or b):	Method a) used	P
	a) In the measurement device of disconnection device (e.g. current transducer, resistor), a DC current of 1A is impressed. The disconnection must be done within 0.2s.		P
	b) Through fault simulation and by means of measurement, it is determined whether a disordered system operation with a DC component of feed in current of more than 1A will lead to disconnection within 0.2s.		N/A
6.6	Detection of island operation		P
	The test on disconnection due to unintended islanding operation shall comply with DIN VDE V 0124-100 (VDE V 0124-100):2012-07, 5.4.6.		P
7	**Production test**		N/A
	Before shipment of automatic disconnection device, each manufacturer shall undertake the production test in sense of safety related parameter.	See manufacturer's work instruction for routine test	N/A
8	**Installation specifications**		P
	Initial and repeated test of automatic disconnection device besides the production test can be waived. If the automatic disconnection device is installed as independent device, it shall not used in TN-C system. It is accepted for TN-C-S system in the case.		P

Clause	Requirement – Test	Measuring result – Remark	Verdict

6.1	TABLE: functional safety(fault condition tests)		P
	ambient temperature (°C) .....:	N/A(at the prevailing ambient temperature)	—

No.	component No.	fault	test voltage (V)	test time	fuse No.	fuse current (A)	Result
1	PCS	overload	MAINS:400; PV: 640	5 hours	-	-	Refer to table 4.3 – heating test. For equipment in which the output voltage is designed to collapse when a specified overload current is reached, the overload is slowly increased to the point of maximum output power before the point which causes the output voltage to collapse. No excessive temperature observed, pls. refer to above table of heating test. No other hazard.
2	DC+ to DC-	reverse	MAINS:400; PV: 640	10min	-	-	The inverter did not start to operate. The inverter protected by short-circuit diode in boost circuit. No output no power feed into grid. No other components damage, no hazard
3	Output L1 to L2	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears.
	Output L1 to L3	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears.
	Output L2 to L3	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears.
	Output L1 to N/G	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears.
	Output L2 to N/G	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears.

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Output L3 to N/G	Short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears. Max. output fault current(peak and duration): 38,5A@5,7ms
	L1&L2&L3	short	MAINS:400; PV: 640	10 min	-	-	The external circuit breaker operated. Unit shutdown. Inverter shows: “utility lost”. No component was damaged. No hazard appears. Max. output fault current(peak and duration): 81,5A@27ms
4	DC+ to DC -	de-energized, with diode in boost circuit shorted	MAINS:400; PV: 640	10min	-	-	The inverter in standby operation mode, after several minutes, the PCS shut down, all grids relays disconnected. No backfeed current and voltage observed in PV side from mains. No components damaged, no hazard.
		de-energized, with one group of relays contacts shorted	MAINS:400; PV: 640	10min	-	-	The inverter in standby operation mode, after several minutes, the PCS shut down, another group of relays disconnected. No backfeed current and voltage observed in PV side from mains. No components damaged, no hazard.
		de-energized, software fault, relay control to closed	MAINS:400; PV: 640	10min	-	-	The inverter in standby operation mode, after several minutes, the PCS shut down. No backfeed current and voltage observed in PV side from mains. No components damaged, no hazard.
5	DC source disconnected	with one group of relays contacts shorted	MAINS:400; PV: 640	10min	-	-	The inverter in standby operation mode, after several minutes, the PCS shut down, another group of relays disconnected. No backfeed current and voltage observed in PV side from mains. No components damaged, no hazard.

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Mains outage, loss of one phase	with one group of relays contacts shorted	MAINS:400; PV: 640	10min	-	-	Inverter cut off for immediately due to islanding detection. No backfeed voltage observed onto Mains side from PV. No output no power feed into grid. No components damaged, no hazard. Inverter shows: “utility lost”.
	Mains outage, loss of three phase	with one group of relays contacts shorted	MAINS:400; PV: 640	10min	-	-	Inverter cut off for immediately due to islanding detection. No backfeed voltage observed onto Mains side from PV. No output no power feed into grid. No components damaged, no hazard. Inverter shows: “utility lost”.
6	L1, L2, L3	reversed	MAINS:400; PV: 640	10min	-	-	The PCS still in normal operation which feed power into grid.
7	R119	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
8	Boost HCT104 Pin5-Pin6	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
9	D100	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. No component was damaged. No hazards.
10	L100(Boost ZVT)	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down. Q103damangd. No hazards
11	Q103 G-S (Boost ZVS)	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
12	Q103 G-D (Boost ZVS)	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down. Q103damangd. No hazards
13	Q103 D-S (Boost ZVS)	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
14	D103(Inv Drive)	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
15	Input Boost choke	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately, Q106 was damaged. No hazards

Clause	Requirement – Test	Measuring result – Remark	Verdict

16	Q106 G-S (Boost Main FET)	Short	MAINS:400; PV: 640	10min	-	-	Inverter work normally, no component was damaged. No hazards
	Q106 G-D	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately, Q106 was damaged. No hazards
	Q106 D-S	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
17	C102 (Boost ZVT capacitor)	Short	MAINS:400; PV: 640	10min	-	-	Inverter runs at full load normally. Input and output no obviously change. No component was damaged.
18	U301 Pin17-Pin18	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U301 Pin15-Pin18	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
	U301 Pin15-Pin17	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
	U301 Pin19-Pin18	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U301 Pin15-Pin19	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
	U301 Pin12-Pin13	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. LCD showed DCI fault. No component damaged. No hazards
	U301 Pin9- Pin8	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
	U301 Pin18-Pin13	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
	U301 Pin15-Pin19	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. U301 damaged . No hazard appears.
19	D213(SPS diode)	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down. R213 Damaged. No hazards
20	TX202(SPS)	Pin6 to pin 7 Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards

Clause	Requirement – Test	Measuring result – Remark	Verdict

	TX202(SPS)	Pin7 to pin 8 Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	TX202(SPS)	Pin8 to pin 9 Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	TX202(SPS)	Pin9 to pin 10 Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
21	Q212 D-S	Short	MAINS:400; PV: 640	10min	-	-	Inverter works normally, after 5 mins, check the inverter. Thermal fuse F203 broken, no hazard appears.
22	C313 bus cap	Short	MAINS:400; PV: 640	10min	-	-	Inverter shutdown immediately. no component damaged. No hazards
23	R348 Bus sampling R	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down and disconnect from grid immediately. No component was damaged. No hazards.
24	U301 COMM Opto-coupler Pin1-pin2	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U301 COMM Optocoupler Pin3-pin4	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U301 COMM Opto-coupler Primary Pin1	Open	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U301 COMM Opto-coupler Primary Pin3	Open	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
25	U201COMM Opto-coupler Pin2-Pin8	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U201COMM Opto-coupler Pin2-Pin6	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards

Clause	Requirement – Test	Measuring result – Remark	Verdict

	U201COMM Opto-coupler Pin2-Pin5	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U201COMM Opto-coupler Pin3-Pin8	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U201COMM Opto-coupler Pin3-Pin6	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
	U201COMM Opto-coupler Pin3-Pin5	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
26	U5 pin1 to pin2	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. No component was damaged. No hazards.
	U5 pin1	Open	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. No component was damaged. No hazards.
27	D103 (Primary side of TX101)	Short	MAINS:400; PV: 640	10min	-	-	Inverter worked normally, input and output no obvious changes. no component was damaged. No hazards
28	D102 (Secondary side of TX101)	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately No component was damaged. No hazard appears.
29	COMM insulation transformer TX101, pin 9 to pin 10	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately, Uoc:5V/Isc:0,25A;
30	Main CPU (U401)Pin84 to Pin3 3.3V to gnd	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. No component was damaged. No hazards.
31	Slave CPU(U501) Pin36 to Pin21 3.3V to gnd	Short	MAINS:400; PV: 640	10min	-	-	Inverter shut down immediately. No component was damaged. No hazards.

Clause	Requirement – Test	Measuring result – Remark	Verdict

32	Output, BOOST NTC(NTC100)	Open	MAINS:400; PV: 640	120min	-	-	Keep inverter running under 60°C ambient temp. until the inverter thermal become stable. Open the NTC under Boost MOSFET. Inverter runs normally, input and output no obviously change. The thermal keeps stable.
33	R437 L sampling R before RY400	Short	MAINS:400; PV: 640	10min	-	-	Inverter work normally, input and output no obviously change. No component was damaged.
34	R436 L sampling R before RY401	Short	MAINS:400; PV: 640	10min	-	-	Inverter work normally, input and output no obviously change. No component was damaged.
35	Relay RY400, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY402, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY403, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY404, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY405, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY406, contacts	C-E Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Relay RY407, contacts	Short before start-up	MAINS:400; PV: 640	10min	-	-	Unit does not start up, Error message: Relay Check failure. No hazard, no damage.
	Ls line sampling resistor R437 before RY400	Open before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Fail". No component was damaged. No hazard appears.
	Q402	D - S short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears.

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Q402	G-D Short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
	Q402	G-S Short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
	D415	Short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". Q406 was damaged. No hazard appears
	D414	Short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure".Q403 was damaged. No hazard appears
	U401	Pin 66 to GND short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
	U401	Pin 65 to GND short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
	U401	Pin 64 to GND short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
	U501	Pin 40 to GND short before start-up	MAINS:400; PV: 640	10min	-	-	The inverter can't start to operate. Inverter LCD shows: "Relay Check Failure". No component was damaged. No hazard appears
36	Grid voltage monitoring for R phase, R431	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
	Grid voltage monitoring for R phase, R432	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
	Grid voltage monitoring for R phase, R432	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.

Clause	Requirement – Test	Measuring result – Remark	Verdict

Grid voltage monitoring for S phase, R459	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring for S phase, R460	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring for S phase, R460	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring for T phase, R521	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring for T phase, R522	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring for T phase, R522	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring for N phase, R461	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring for N phase, R464	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring, R462	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring, R150	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring, C125	short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring, U101A	Pin3-GND short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Utility loss. No hazard, no damage.
Frequency monitoring, C115	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.

Clause	Requirement – Test	Measuring result – Remark	Verdict

Frequency monitoring, R120	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Frequency monitoring, C311	short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Grid voltage monitoring, R268	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring, C114	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring	U101C pin 9 to GND short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Utility loss. No hazard, no damage.
Frequency monitoring, C113	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Frequency monitoring, R144	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Frequency monitoring, C333	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Grid voltage monitoring, R280	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Vac failure. No hazard, no damage.
Grid voltage monitoring, C103	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Consistent failure. No hazard, no damage.
Grid voltage monitoring	U101D pin 12-GND short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Utility loss. No hazard, no damage.
Frequency monitoring, C149	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
Frequency monitoring, R175	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Frequency monitoring, C311	Short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Fac failure. No hazard, no damage.
37	Loss power of main CPU(U401)	C430 short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid. No hazard, no defect
	Loss power of main CPU(U401)	C447 short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid. No hazard, no defect
38	Loss power of Slave CPU(U501)	Pin XRS-GND short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid. The inverter keeps restart state. No hazard, no defect.
39	RCMU detect, R403	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: GFCI failure. No hazard, no defect
	RCMU detect, R423	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Ground I failure. failure.. No hazard, no defect
	RCMU detect, U402B	Pin6-GND short	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: GFCI failure. No hazard, no defect
	RCMU detect, R407	Open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: Ground I failure. No hazard, no defect
40	Communication between CPUs	U401 pin 96 open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: SPI failure. No hazard, no defect
	Communication between CPUs	U401 pin 97 open	MAINS:400; PV: 640	10min	-	-	Unit disconnect immediately from the grid, Error message: SPI failure. No hazard, no defect

Clause	Requirement – Test	Measuring result – Remark	Verdict

Note 1: Single fault tests were carried out on model GW25K-DT, because the electric circuit and assembling for other models are same to GW25K-DT.
Note 2: All single fault tests were carried out by a 30A non-time delay fuse connected between the protective earthing terminal and the protective earthing conductor in the test setup which had not opened during the tests. All single fault tests were conducted with the AC output protected by external circuit breaker provided in all live connections to the AC supply.

Note 3: 4.4.4.5 Output short circuit - Short L to N/G, short L1-L2-L3

The test was repeated 4 times so that short occurred in the different positions(0°, 90°, 180°, 270°) of the line cycle.
When shorting the unit, the output source is to be disconnected by a relay or similar device.
As well, one test with all current-carrying terminals of the port shorted together conducted.

Note 4: The equipment was placed on white tissue-paper covering a softwood surface and covering the equipment with cheesecloth during the fault testing, no emission of molten metal, burning insulation, or flaming or glowing particles from the fire enclosure, and there was no charring, glowing, or flaming of the cheesecloth.
Note 5: After test, the inverter pass the dielectric test.
Note 6: No other hazard(e.g. chemical, expulsion) observed after each test.

6.2	**TABLE: Connection condition and synchronization, short-time interruption**			**P**
Connection conditions				
Iteration	Transient program(Frequency connection conditions)	Holding time	Restore time	Power recover
Frequency	Underfrequency (setp change from 50,00Hz to 47,40 within ½ cycle)	4s@47,40Hz	N/A	Power rise curve:<10%PEmax
	Underfrequency (setp change from 47,40 Hz to 47,45 within ½ cycle)	120s@47,45Hz	Not occured	
	Return to nominal (setp change from 47,45 Hz to 47,55 within ½ cycle)	120s+10 minutes @47,55Hz	Reconnection: 63s	

Clause	Requirement – Test	Measuring result – Remark	Verdict

Frequency	Overfrequency (setp change from 50,00Hz to 51,55 within ½ cycle)	4s@51,55Hz	N/A	Power rise curve:<10%PEmax
	Overfrequency (setp change from 51,55 Hz to 50,10 within ½ cycle)	120s@50,10Hz	Not occured	
	Return to Nominal (setp change from 50,10 Hz to 50Hz within ½ cycle)	120s+10 minutes @50Hz	Reconnection:62s,	
Iteration	Transient program (Voltage connection conditions)	Holding time	Restore time	Power recover
L1-N	Overvoltage(setp change from 230V to 266,8V within ½ cycle)	4s@266,8V	N/A	Power rise curve:<10%PEmax
	(setp change from 266,8V to 190,9V within ½ cycle)	120s@255,3V	Not occured	
	Return to 250,7V	120s+10 minutes @250,7V	Reconnection:62s,	
L2-N	Undervoltage (setp change from 230V to 181,7V within ½ cycle)	4s@181,7V	N/A	Power rise curve:<10%PEmax
	(setp change from 190,9V to V within ½ cycle)	120s@190,9V	Not occured	

Clause	Requirement – Test	Measuring result – Remark	Verdict

	Return to 197,8V	120s+10 minutes @197,8V	Reconnection:62s,	
L3-N	Overvoltage(setp change from 230V to 266,8V within ½ cycle)	4s@266,8V	N/A	Power rise curve:<10%PEmax
	(setp change from 266,8V to 255,3V within ½ cycle)	120s@255,3V	Not occured	
	Return to 250,7V	120s+10 minutes @250,7V	Reconnection:62s,	
L1-N	Undervoltage (setp change from 230V to 181,7V within ½ cycle)	4s@181,7V	N/A	Power rise curve:<10%PEmax
	(setp change from 190,9V to V within ½ cycle)	120s@190,9V	Not occured	
	Return to 197,8V	120s+10 minutes @197,8V	Reconnection:62s,	
L2-N	Undervoltage (setp change from 230V to 181,7V within ½ cycle)	4s@181,7V	N/A	Power rise curve:<10%PEmax
	(setp change from 193,2V to V within ½ cycle)	120s@190,9V	Not occured	
	Return to 197,8V	120s+10 minutes @197,8V	Reconnection:62s,	
L3-N	Undervoltage (setp change from 230V to 181,7V within ½ cycle)	4s@181,7V	N/A	Power rise curve:<10%PEmax

Clause	Requirement – Test	Measuring result – Remark	Verdict

	(setp change from 193,2V to V within ½ cycle)	450s@190,9V	Not occured
	Return to 197,8V	450s+10 minutes @197,8V	Reconnection:62s,

Short-time interruption			
Transient program (fluctuation):	Iteration	Disconnect time (ms)	Reconnection time (s)
Short-time under voltage – 2s fluctuation@0,77Un	1- L1-N	<200ms	63s
	2- L2-N	<200ms	63s
	3- L3-N	<200ms	63s
Short-time under voltage – 4s fluctuation@0,77Un	1- L1-N	<200ms	62s
	2- L2-N	<200ms	62s
	3- L3-N	<200ms	62s

6.3	**TABLE: Voltage monitoring**			**P**
Rise-in-voltage protection U>>				
Iteration	Measured voltage (V)			deviation from set point [%]
	Phase L1	Phase L2	Phase L3	
measurement of the phase-to-neutral voltage				
1- Phase to neutral voltage L1-N	265,6	230	230	+0,48
2- Phase to neutral voltage L1-N	265,6	230	230	+0,48

Clause	Requirement – Test	Measuring result – Remark	Verdict

3- Phase to neutral voltage L1-N	265,7	230	230	+0,52
Max. phase to neutral voltage L1-N(V)/ Max deviation[%]	265,7/+0,52			
1- Phase to neutral voltage L2-N	230	264,6	230	+0,04
2- Phase to neutral voltage L2-N	230	264,8	230	+0,13
3- Phase to neutral voltage L2-N	230	264,6	230	+0,04
Max. phase to neutral voltage L2-N(V)/ Max deviation[%]	264,8/+0,13			
1- Phase to neutral voltage L3-N	230	230	266,2	+0,74
2- Phase to neutral voltage L3-N	230	230	266,1	+0,70
3- Phase to neutral voltage L3-N	230	230	266,2	+0,74
Max. phase to neutral voltage L3-N(V)/ Max deviation[%]	266,2/+0,74			
measurement of the phase-to-phase voltages				
1- Phase to phase voltage L1-L2	460,1	253(L2-N)	253(L3-N)	+0,03
2- Phase to phase voltage L1-L2	460,1	253(L2-N)	253(L3-N)	+0,03
3- Phase to phase voltage L1-L2	459,9	253(L2-N)	253(L3-N)	-0,03
Max. phase to phase voltage L1-L2(V)/ Max deviation[%]	460,1/+0,03			
1- Phase to phase	253(L1-N)	253(L2-N)	459,8	-0,05

Clause	Requirement – Test	Measuring result – Remark	Verdict

voltage L1-L3				
2- Phase to phase voltage L1-L3	253(L1-N)	253(L2-N)	459,5	-0,13
3- Phase to phase voltage L1-L3	253(L1-N)	253(L2-N)	459,5	-0,13
Max. phase to phase voltage L1-L3(V)/ Max deviation[%]	459,5/-0,13			
1- Phase to phase voltage L2-L3	253(L1-N)	460,9	253(L3-N)	+0,23
2- Phase to phase voltage L2-L3	253(L1-N)	460,8	253(L3-N)	+0,20
3- Phase to phase voltage L2-L3	253(L1-N)	460,8	253(L3-N)	+0,20
Max. phase to phase voltage L2-L3(V)/ Max deviation[%]	460,9/+0,23			

Iteration	Disconnect time (ms)
1- Phase L1-N	169
2- Phase L1-N	128
3-Phase L1-N	127
Max. break time, L1-N(ms)	189
1- Phase L2-N	175
2- Phase L2-N	183
3-Phase L2-N	179
Max. break time, L2-N(ms)	183

Clause	Requirement – Test	Measuring result – Remark	Verdict

1- Phase L3-N	182
2- Phase L3-N	179
3-Phase L3-N	181
Max. break time, L3-N(ms)	182
1- Phase L1-L2	179
2- Phase L1-L2	172
3-Phase L1-L2	169
Max. break time, L1-L2(ms)	179
1- Phase L1-L3	172
2- Phase L1-L3	173
3-Phase L1-L3	168
Max. break time, L1-L3(ms)	173
1- Phase L2-L3	175
2- Phase L2-L3	184
3-Phase L2-L3	168
Max. break time, L2-L3(ms)	184

Voltage drop protection U<

Iteration	Measured voltage (V)			deviation from set point [%]
	Phase L1	Phase L2	Phase L3	

Clause	Requirement – Test	Measuring result – Remark	Verdict

measurement of the phase-to-neutral voltage				
1- Phase to neutral voltage L-N	185,2	230	230	+0,52
2- Phase to neutral voltage L-N	185,2	230	230	+0,52
3- Phase to neutral voltage L-N	185,2	230	230	+0,52
Min. phase to neutral voltage L-N(V)/ Max. deviation[%]	185,2/+0,52			
1- Phase to neutral voltage L2-N	230	184,8	230	+0,35
2- Phase to neutral voltage L2-N	230	184,8	230	+0,35
3- Phase to neutral voltage L2-N	230	184,8	230	+0,35
Min. phase to neutral voltage L2-N(V)/ Max. deviation[%]	184,8/+0,35			
1- Phase to neutral voltage L3-N	230	230	185,6	+0,70
2- Phase to neutral voltage L3-N	230	230	185,6	+0,70
3- Phase to neutral voltage L3-N	230	230	185,5	+0,65
Min. phase to neutral voltage L3-N(V)/ Max. deviation[%]	185,6/+0,70			
measurement of the phase-to-phase voltage				
1- Phase to phase voltage L1-L2	320,1	207(L2-N)	207(L3-N)	+0,03
2- Phase to phase voltage L1-L2	320,1	207(L2-N)	207(L3-N)	+0,03

Clause	Requirement – Test	Measuring result – Remark	Verdict

3- Phase to phase voltage L1-L2	320,1	207(L2-N)	207(L3-N)	+0,03
Min. phase to phase voltage L1-L2(V)/ Max. deviation[%]	320,1/+0,03			
1- Phase to phase voltage L1-L3	207(L1-N)	207(L2-N)	321,2	+0,30
2- Phase to phase voltage L1-L3	207(L1-N)	207(L2-N)	321,2	+0,30
3- Phase to phase voltage L1-L3	207(L1-N)	207(L2-N)	321,2	+0,30
Min. phase to phase voltage L1-L3(V)/ Max. deviation[%]	321,2/+0,30			
1- Phase to phase voltage L2-L3	207(L1-N)	320,7	207(L3-N)	+0,18
2- Phase to phase voltage L2-L3	207(L1-N)	320,7	207(L3-N)	+0,18
3- Phase to phase voltage L2-L3	207(L1-N)	320,7	207(L3-N)	+0,18
Min. phase to phase voltage L2-L3(V)/ Max. deviation[%]	320,7/+0,18			

Iteration	break time (ms)
1- Phase L1-N	172
2- Phase L1-N	178
3- Phase L1-N	171
Max. break time, L1-N(ms)	178
1- Phase L2-N	170
2- Phase L2-N	182

Clause	Requirement – Test	Measuring result – Remark	Verdict

3- Phase L2-N	184
Max. break time, L2-N(ms)	184
1- Phase L3-N	180
2- Phase L3-N	175
3- Phase L3-N	169
Max. break time, L3-N(ms)	180
1- Phase L1-L2	174
2- Phase L1-L2	180
3- Phase L1-L2	175
Max. break time, L1-L2(ms)	180
1- Phase L1-L3	176
2- Phase L1-L3	170
3- Phase L1-L3	173
Max. break time, L1-L3(ms)	176
1- Phase L2-L3	174
2- Phase L2-L3	176
3- Phase L2-L3	179
Max. break time, L2-L3(ms)	179

Clause	Requirement – Test	Measuring result – Remark	Verdict

Rise-in-voltage protection U>

Overvoltage protection according to DIN EN 50160:2011-02

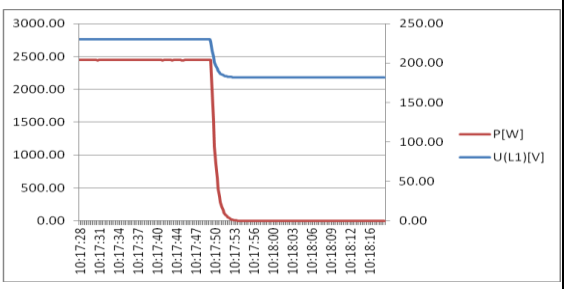
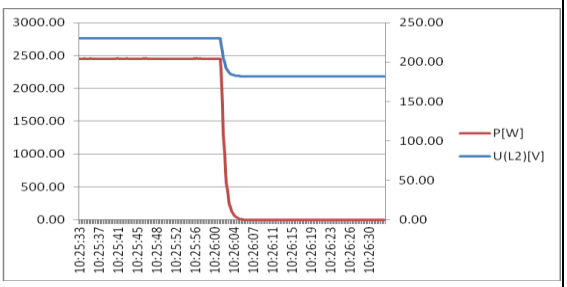
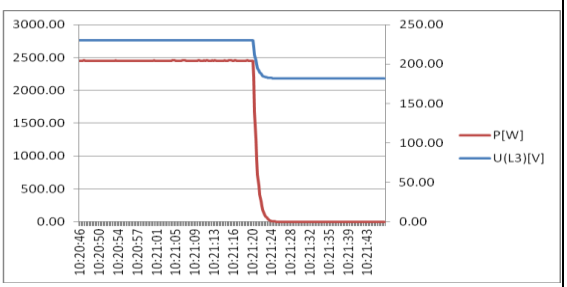
Test program :	Iteration	Total disconnect time (s)/relay trip time (ms)	Reconnection time (≥60s)
600s@Un to 112%Un	1- Phase L1-N	585s/<200ms	See connection conditions and synchronisation
600s@Un to 112%Un	1- Phase L2-N	567s/<200ms	See connection conditions and synchronisation
600s@Un to 112%Un	1- Phase L3-N	578s/<200ms	See connection conditions and synchronisation
600s@Un to 600s@108%Un	1- Phase L1-N	N/A, no trip	N/A
600s@Un to 600s@108%Un	1- Phase L2-N	N/A, no trip	N/A
600s@Un to 600s@108%Un	1- Phase L3-N	N/A, no trip	N/A
600s@106%Un to 114%Un	1- Phase L1-N	275s/<200ms	See connection conditions and synchronisation
600s@106%Un to 114%Un	1- Phase L2-N	278s/<200ms	See connection conditions and synchronisation
600s@106%Un to 114%Un	1- Phase L3-N	269s/<200ms	See connection conditions and synchronisation

Remark: The switch-off time for the test c) may vary due to tolerances of the accuracy of measuring the voltage of the NS protection. A switch-off between 225 s and 375 s after the voltage jump at time within limit deviation (± 1% Un) is the allowed.

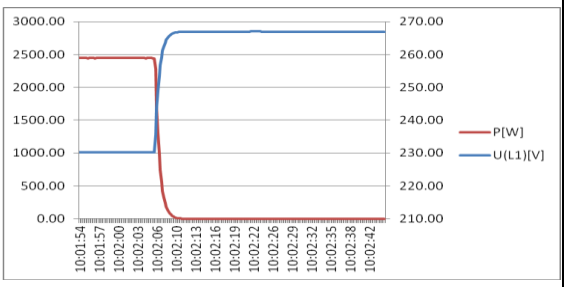
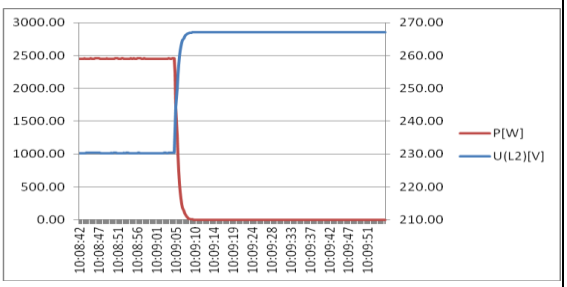
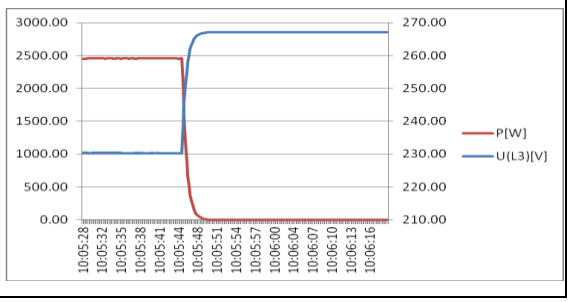
Undervoltage monitoring tolerance verification

Transient program	Iteration	Disconnect time (ms) N/A if Trip did	Oscilloscope recorded waveforms

Clause	Requirement – Test	Measuring result – Remark	Verdict

		not occur	
Undervoltage trip setting point minus 1%Un: 230V to 181,7V	1- Phase L1-N	Trip	
Undervoltage trip setting point plus 1%Un: 230V to 186,3V	1- Phase L1-N	N/A	Continuous operation
Undervoltage trip setting point minus 1%Un: 230V to 181,7V	1- Phase L2-N	Trip	
Undervoltage trip setting point plus 1%Un: 230V to 186,3V	1- Phase L2-N	N/A	Continuous operation
Undervoltage trip setting point minus 1%Un: 230V to 181,7V	1- Phase L3-N	Trip	
Undervoltage trip setting point plus 1%Un: 230V to 186,3V	1- Phase L3-N	N/A	Continuous operation
Overvoltage monitoring tolerance verification			

Clause	Requirement – Test	Measuring result – Remark	Verdict

Overvoltage trip setting point minus 1%Un: 230V to 262,2V	1- Phase L1-N	N/A	Continuous operation
Overvoltage trip setting point plus 1%Un: 230V to 266,8V	1- Phase L1-N	Trip	
Overvoltage trip setting point minus 1%Un: 230V to 262,2V	1- Phase L2-N	N/A	Continuous operation
Overvoltage trip setting point plus 1%Un: 230V to 266,8V	1- Phase L2-N	Trip	
Overvoltage trip setting point minus 1%Un: 230V to 262,2V	1- Phase L3-N	N/A	Continuous operation
Overvoltage trip setting point plus 1%Un: 230V to 266,8V	1- Phase L3-N	Trip	

6.4	**TABLE: Frequency monitoring**	**P**
Test conditions:		
frequency protection *f*< (under frequency), Limit: 47,5Hz		

Clause	Requirement – Test	Measuring result – Remark	Verdict

Iteration	Measured trip frequency (Hz)	Variation of Average and each time from set point(%)
1 – at Un	47,49	-0,02
2– at Un	47,50	0
3– at Un	47,50	0
Min. frequency[Hz]/ deviating[%]	47,49/-0,02	

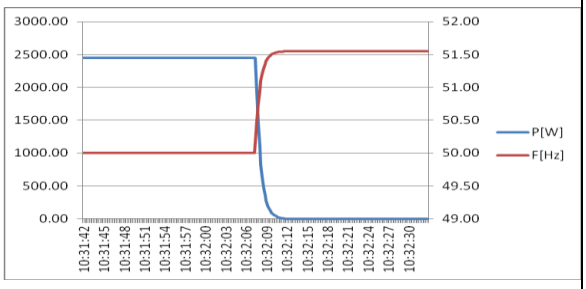
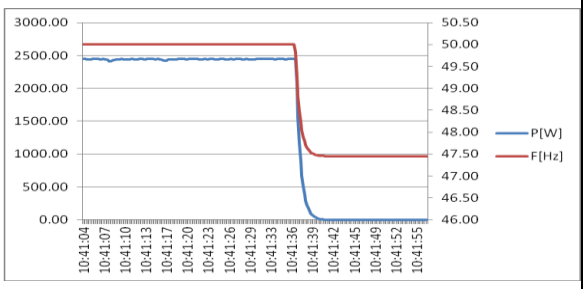
Transient program	Iteration	Disconnect time (ms)
50Hz to 47,4Hz	1	57
50Hz to 47,4Hz	2	65
50Hz to 47,4Hz	3	66
Max. Break time(ms)	66	

frequency protection *f*> (over frequency), Limit: 51,5Hz

Iteration	Measured trip frequency (Hz)	Variation of Average and each time from set point(%)
1 – at Un	51,51	+0,02
2– at Un	51,51	+0,02
3– at Un	51,51	+0,02
Max. frequency [Hz]/deviating[%]	51,51/+0,02	

Transient program	Iteration	Disconnect time (ms)
50Hz to 51,6Hz	1	55
50Hz to 51,6Hz	2	62
50Hz to 51,6Hz	3	59
Max. Break time(ms)	62	

Clause	Requirement – Test	Measuring result – Remark	Verdict

Over frequency monitoring tolerance verification			
Transient program	Iteration	Disconnect time (ms) N/A if Trip did not occur	Oscilloscope recorded waveforms
Overfrequency trip setting point minus 0,1%Fn: 50Hz to 51,45Hz	Phase L1,L2 and L3	N/A	Continuous operation
Overfrequency trip setting point plus 1%Fn: 50Hz to 51,55Hz	Phase L1,L2 and L3	Trip	
Under frequency monitoring tolerance verification			
Transient program	Iteration	Disconnect time (ms) N/A if Trip did not occur	Oscilloscope recorded waveforms
Underfrequency trip setting point minus 0,1%Fn: 50Hz to 47,45Hz	Phase L1,L2 and L3	Trip	
Underfrequency trip setting point plus 0,1%Fn: 50Hz to 47,55Hz	Phase L1,L2 and L3	N/A	Continuous operation

6.5	**TABLE: DC current monitoring**	**P**
Power output level		

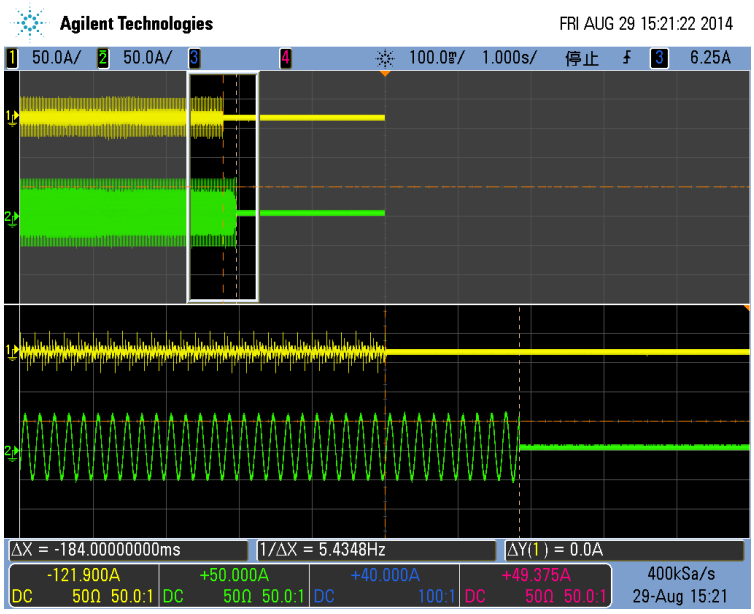
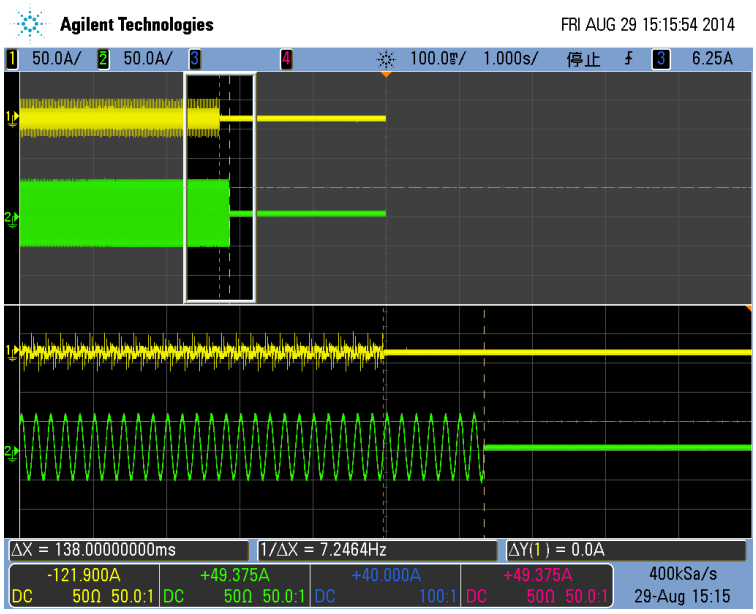
Clause	Requirement – Test	Measuring result – Remark	Verdict

100%	
Test sequence	Disconnecting time (ms)
L1-N (current direction: positive)	162
L2-N (current direction: positive)	149
L3-N (current direction: positive)	158
Test sequence	Disconnecting time (ms)
L1-N (current direction: negative)	164
L1-N (current direction: negative)	168
L1-N (current direction: negative)	165
Max. Break time(ms)	168

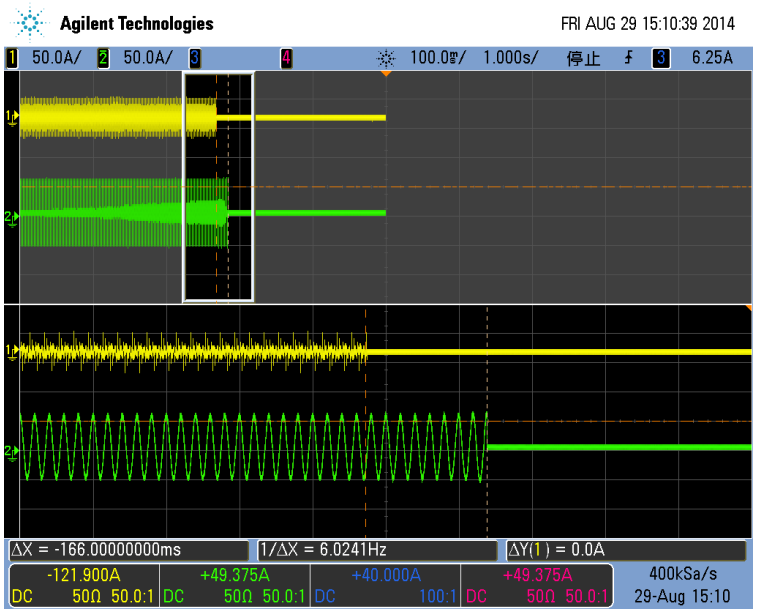
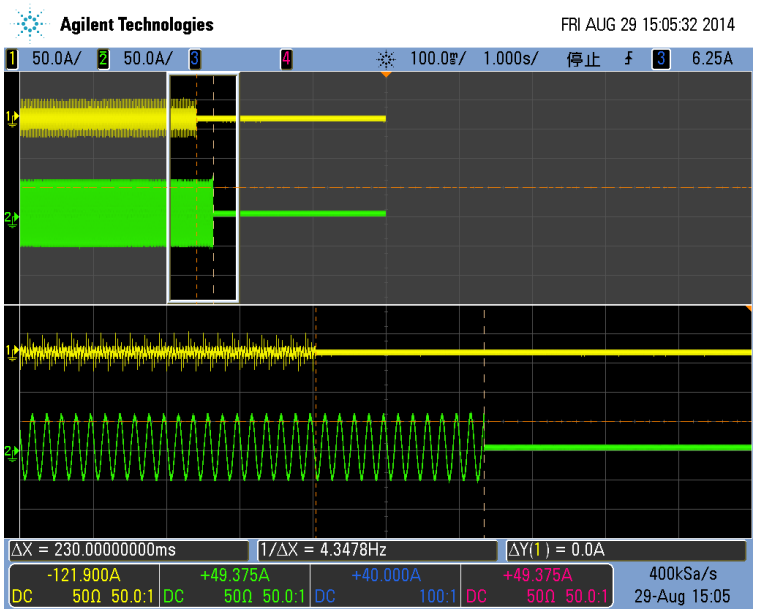
6.6	**TABLE: Islanding detection**				**P**
Rated Frequency = (Hz)	50Hz		Rated Voltage = (Vac)	400/230Vac	
PGU nominal active power (W)	25,000 W				
Iteration Phase L1-N	Power output level				
	100%				
Balance condition	P=8340W	Q_L=19090VA	Q_C=19160VA	$P_{Q.WR}$=67VA	Q=2,29

Osc. parameter	Disconnecting time (ms)	Oscilloscope recorded waveforms

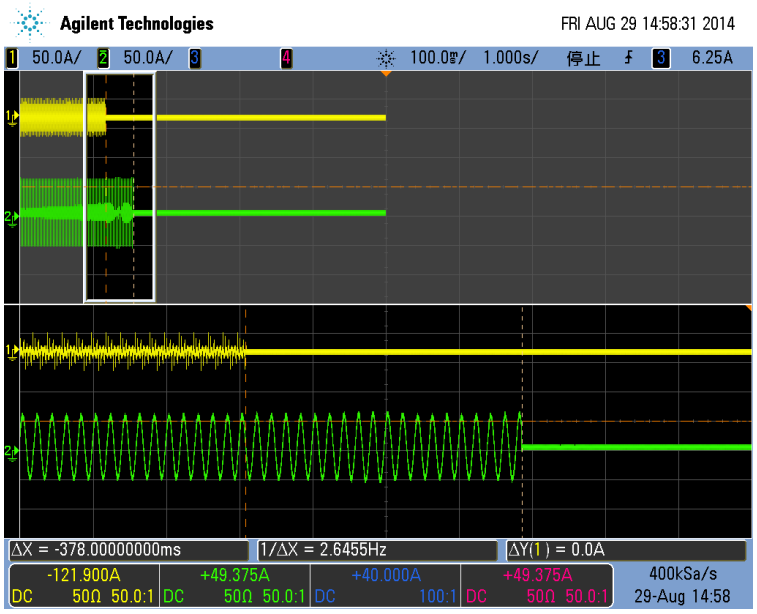
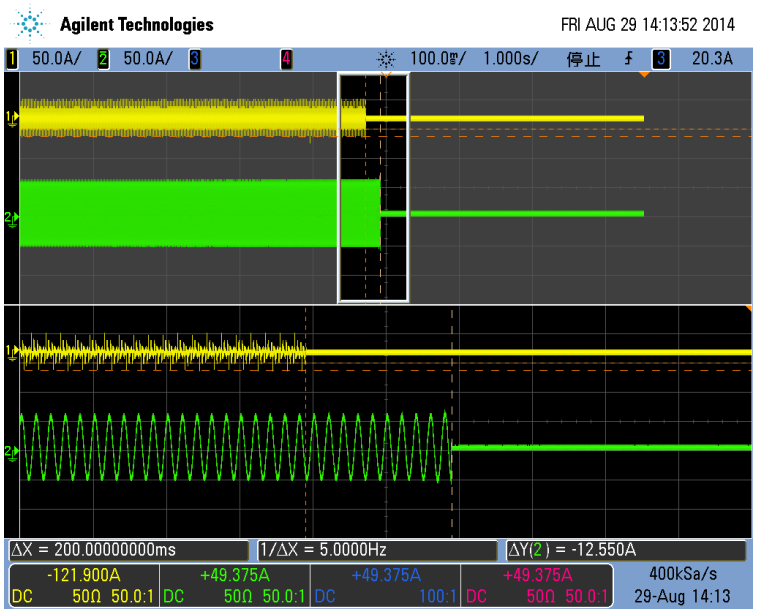
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 5%	184	
- 4%	138	

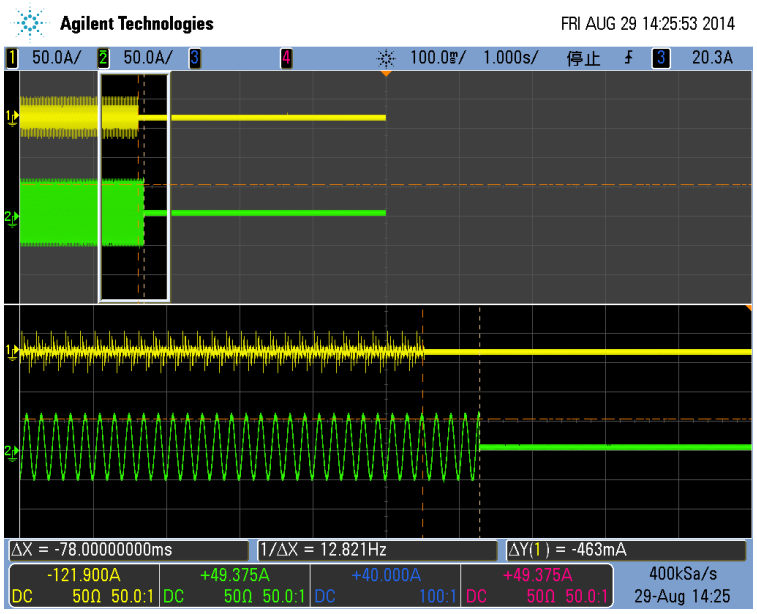
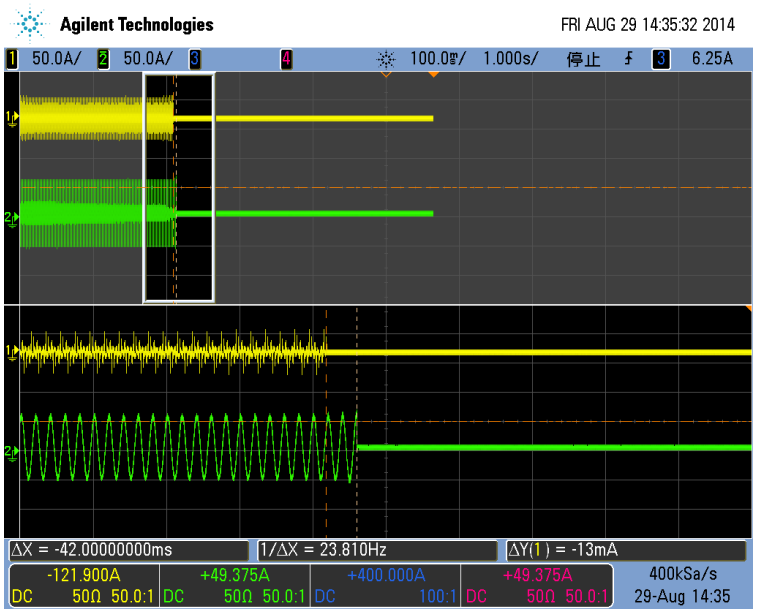
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 3%	166	
- 2%	230	

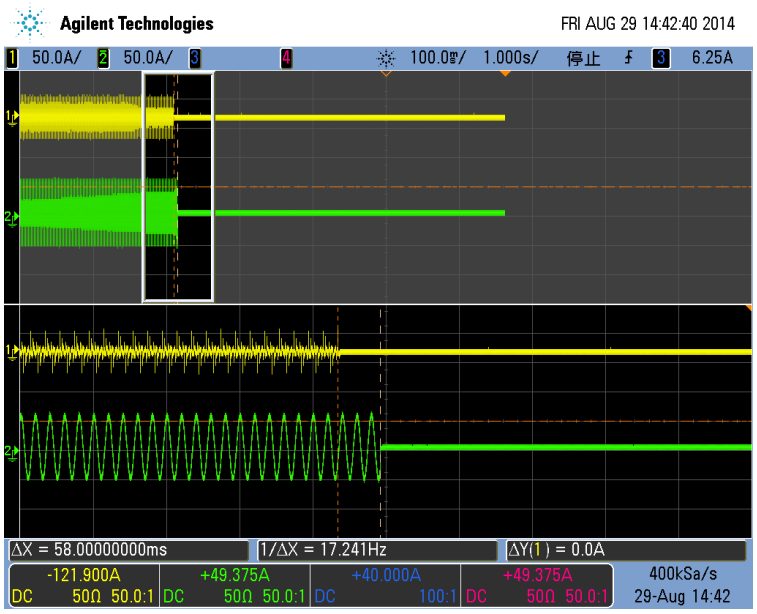
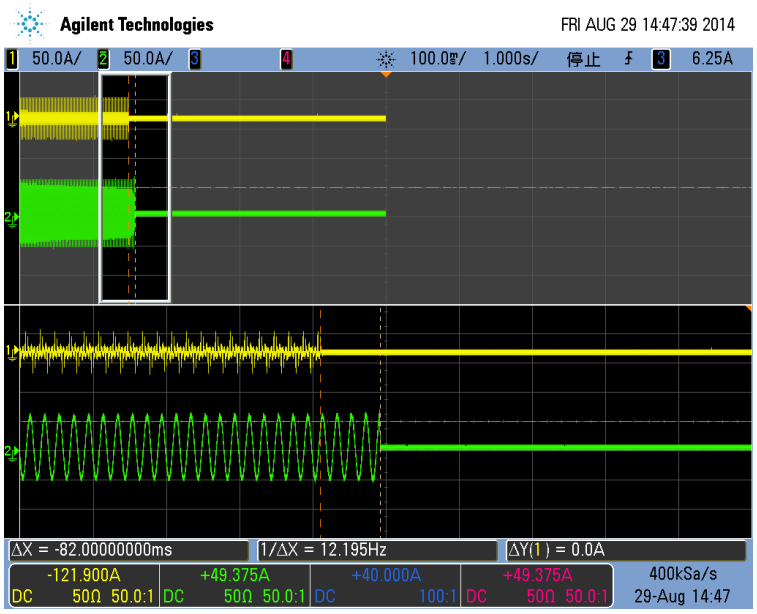
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 1%	378	
0%	200	

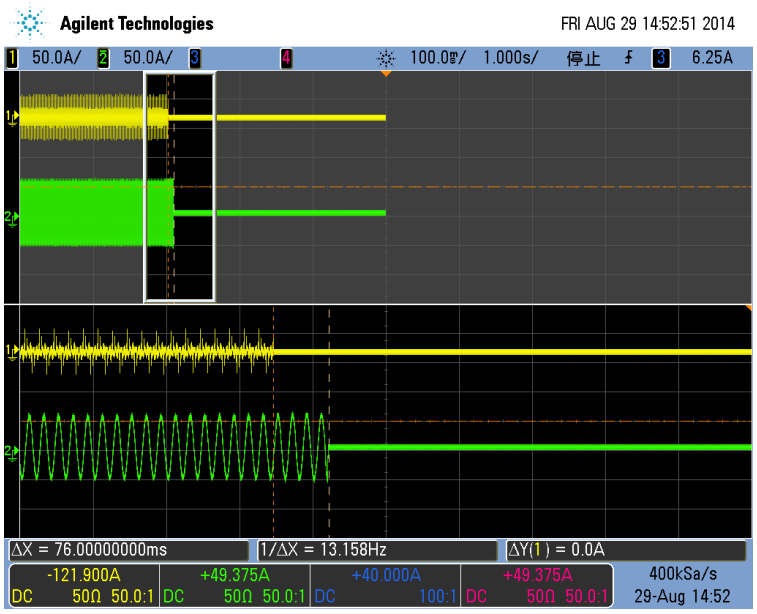
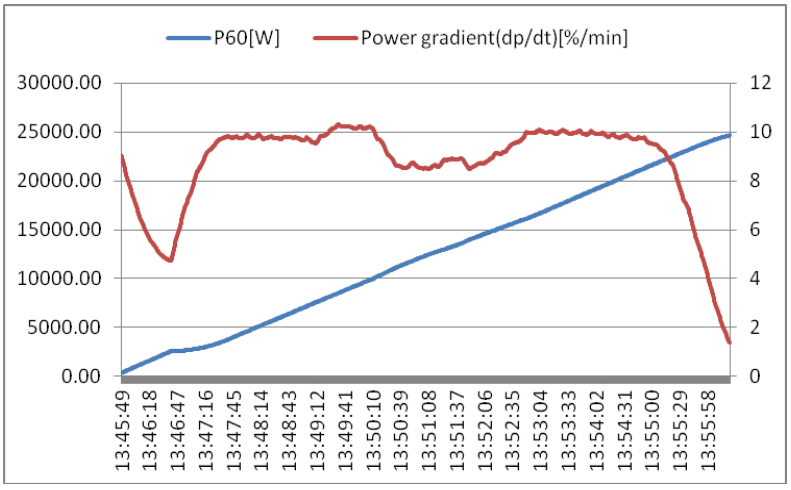
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 1%	78	
+ 2%	42	

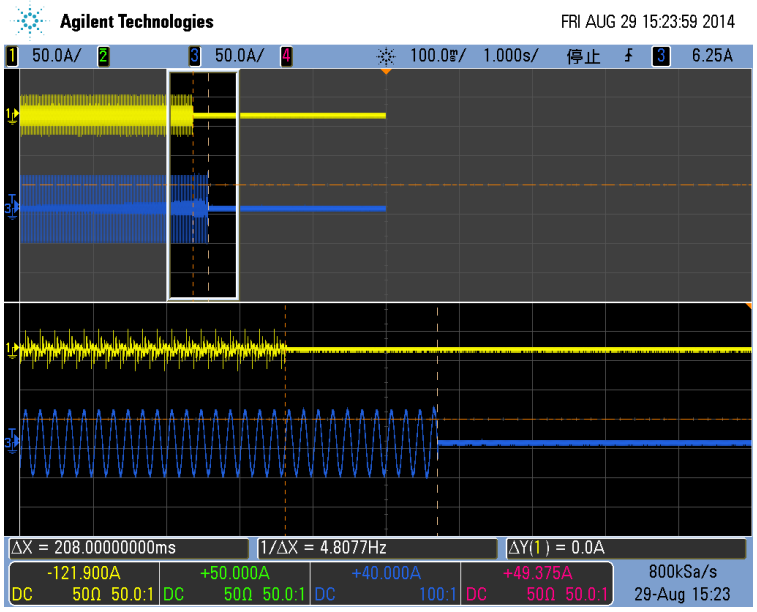
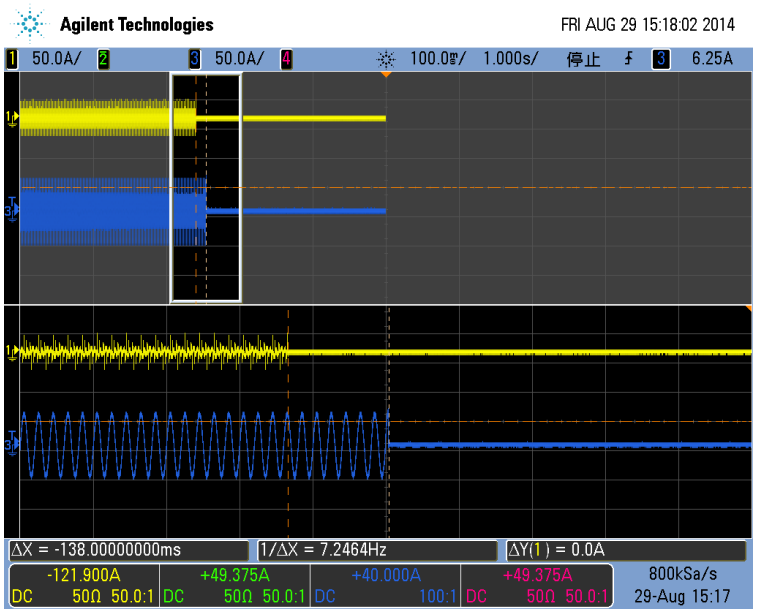
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 3%	58	
+ 4%	82	

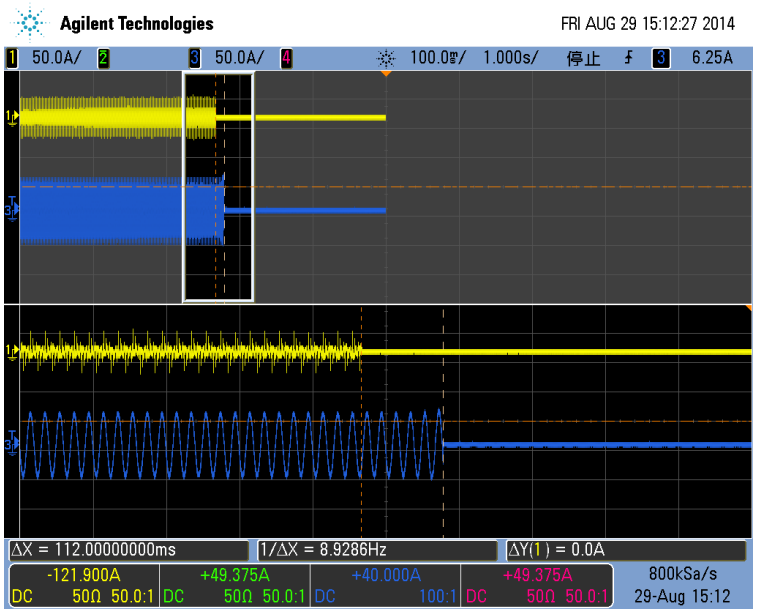
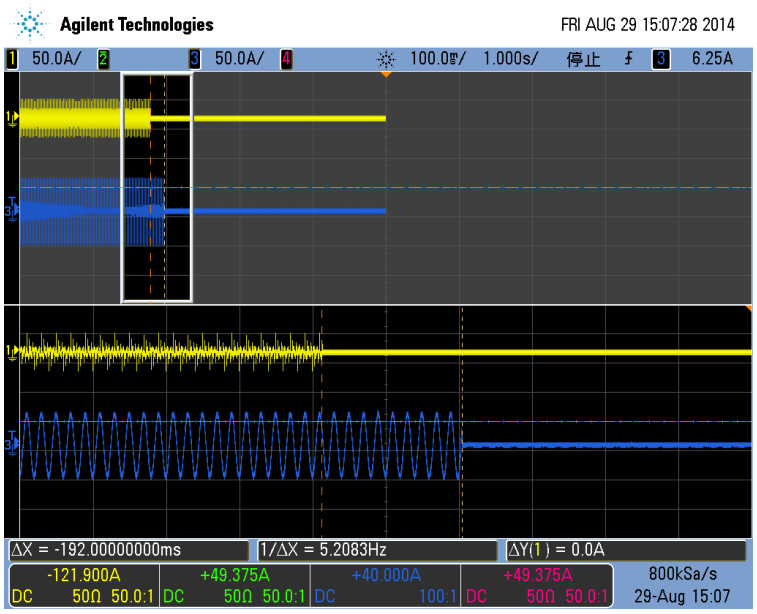
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 5%	76				
Reconnection time and power rise gradient after loss of mains	Reconnection time> 60s and power rise gradient<10%PEmax/min 				
Iteration Phase L2-N	Power output level				
	100%				
Balance condition	P=8340W	Q_L=19080VA	Q_C=19140VA	$P_{Q.WR}$=67VA	Q=2,29

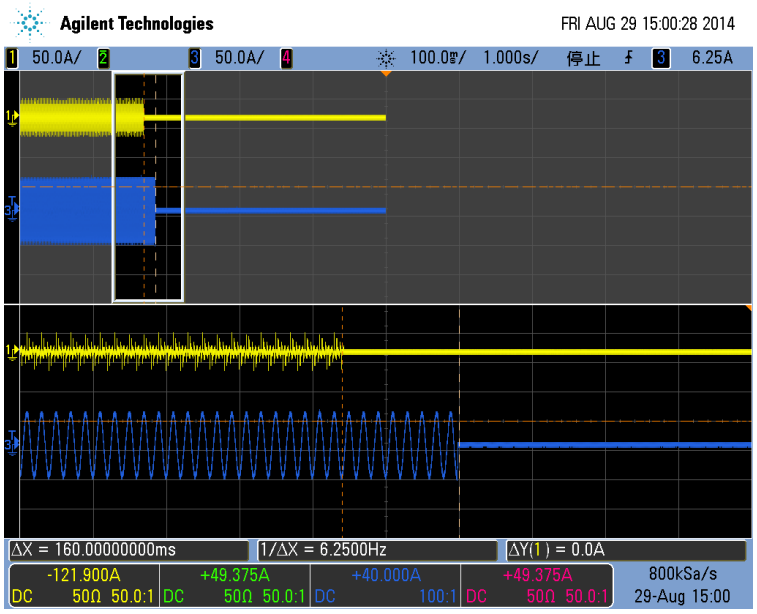
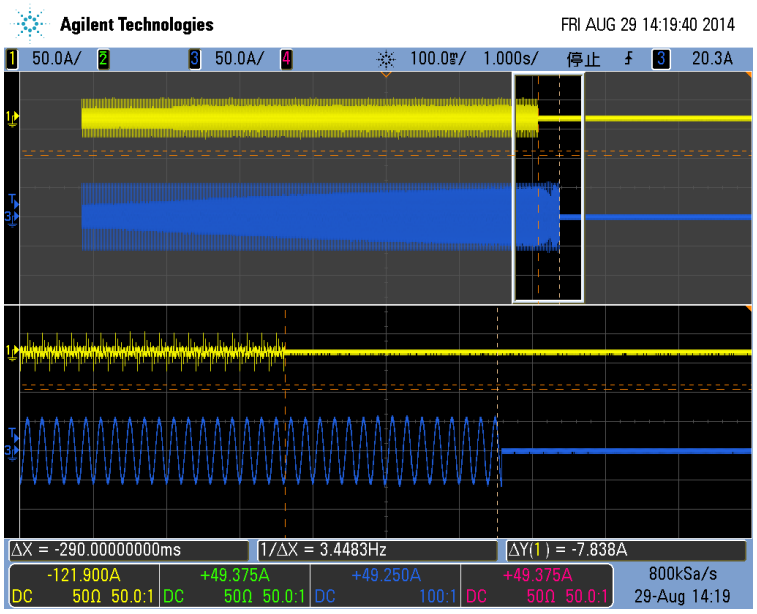
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 5%	208	
- 4%	138	

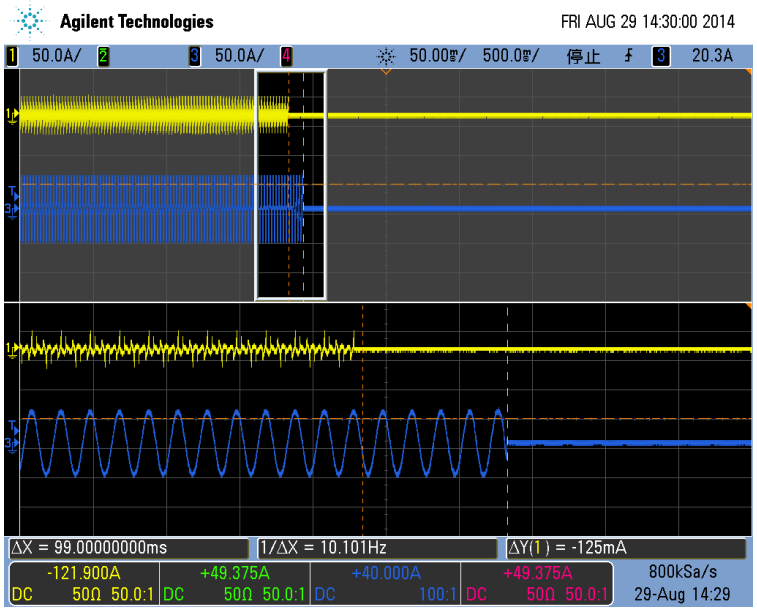
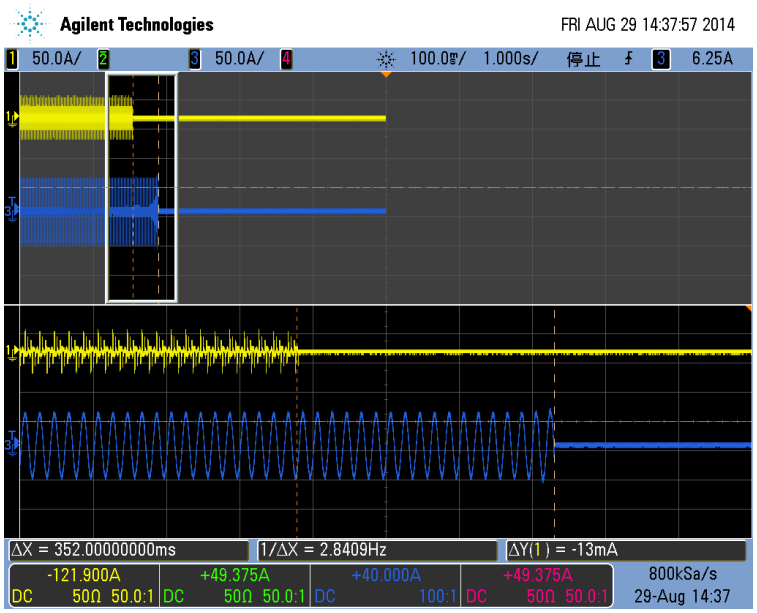
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 3%	112	
- 2%	192	

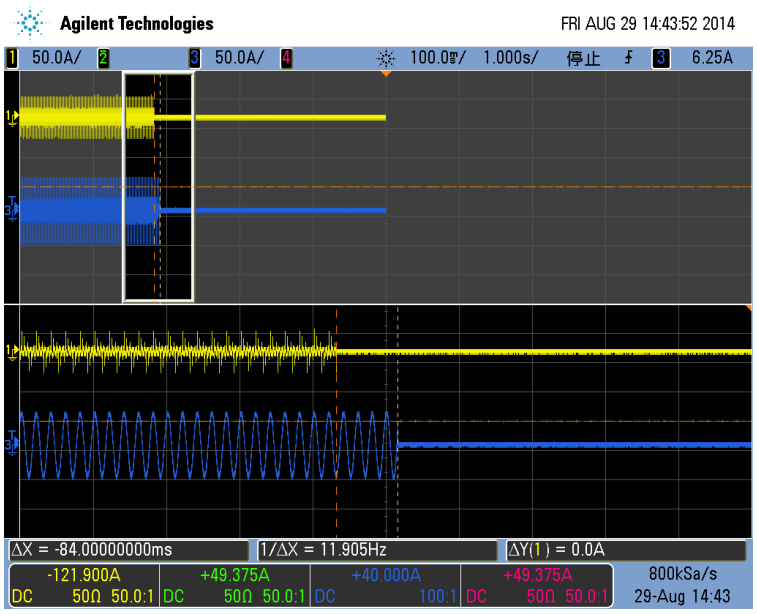
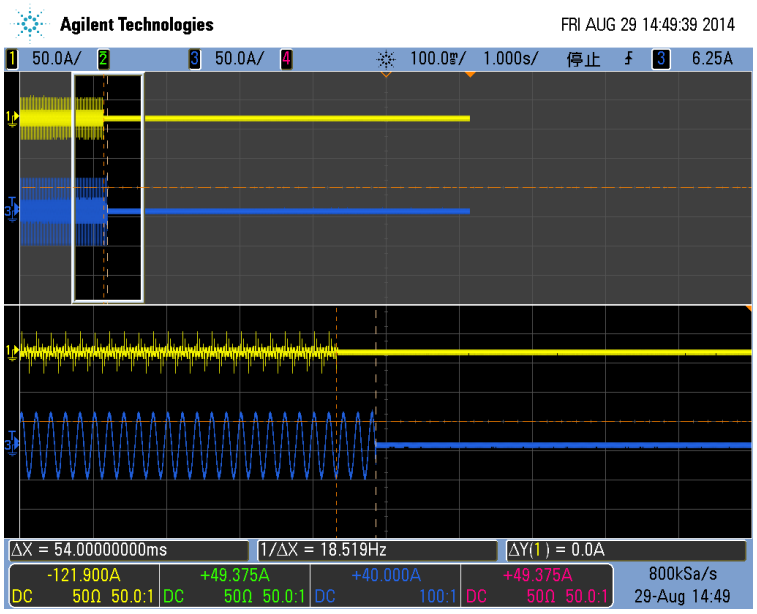
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 1%	160,0	
0%	290	

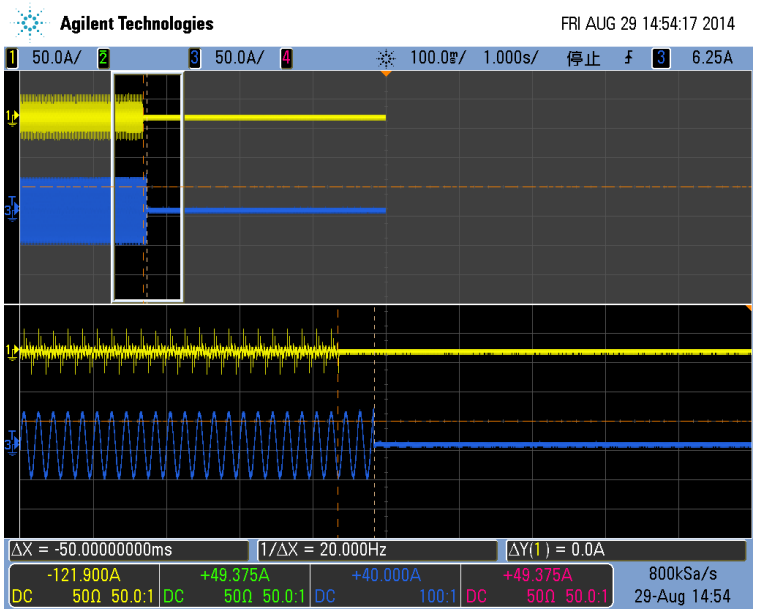
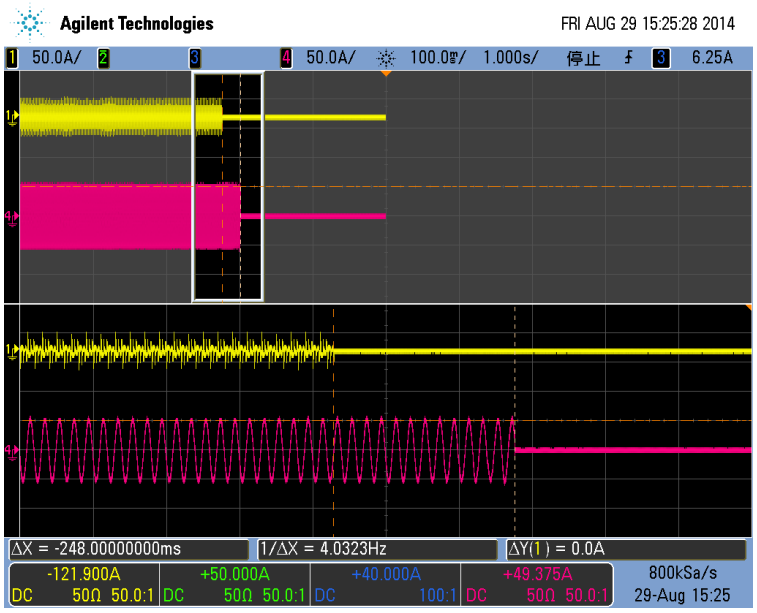
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 1%	99	
+ 2%	352	

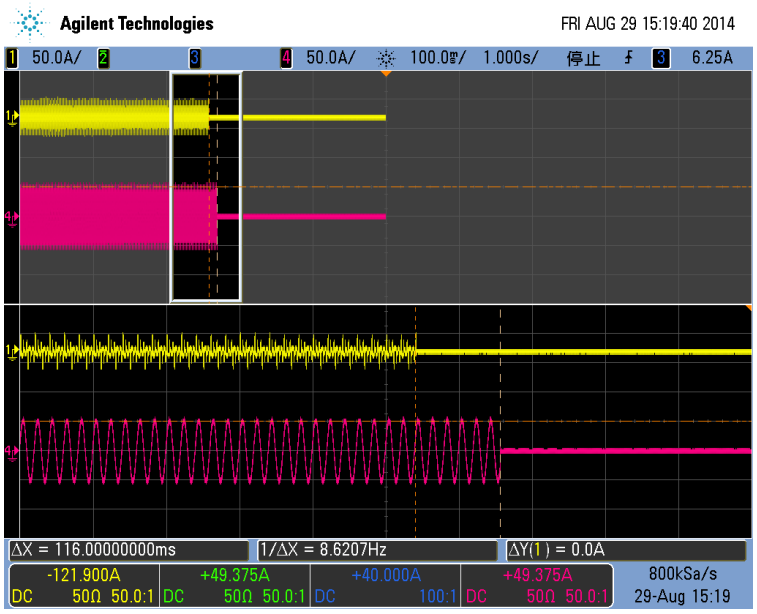
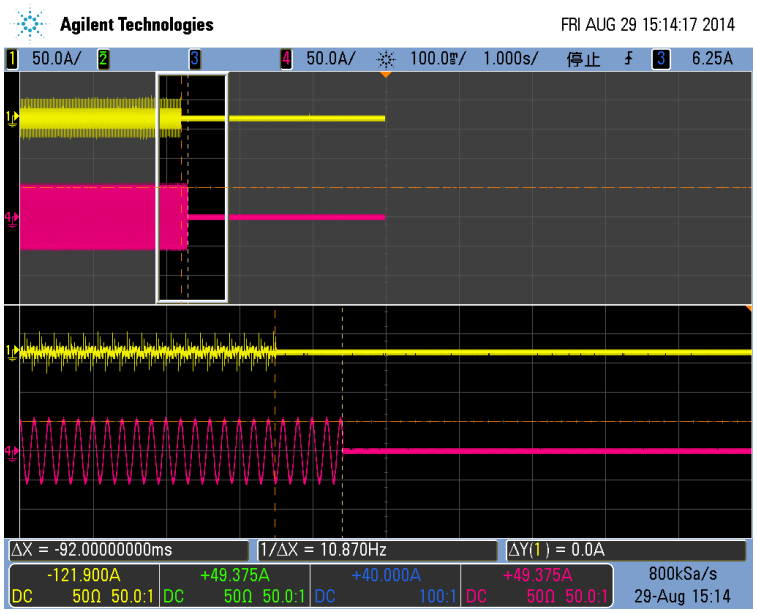
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 3%	84	
+ 4%	54	

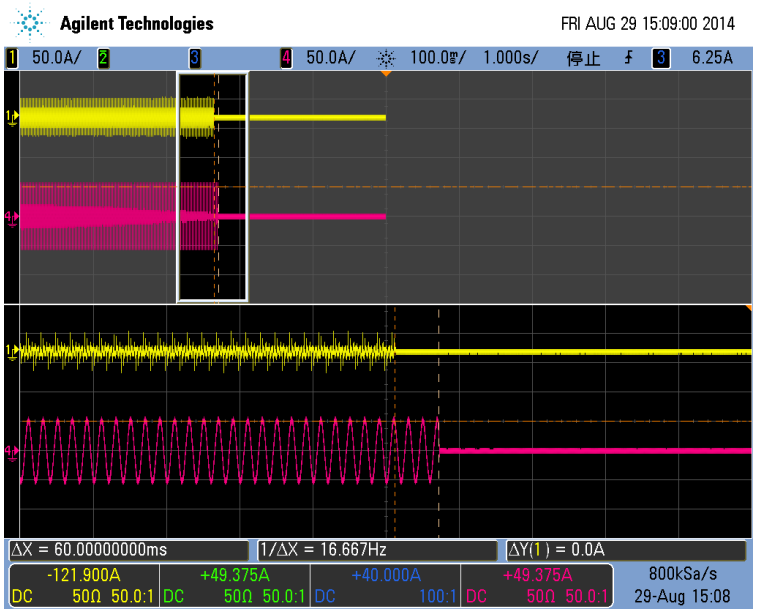
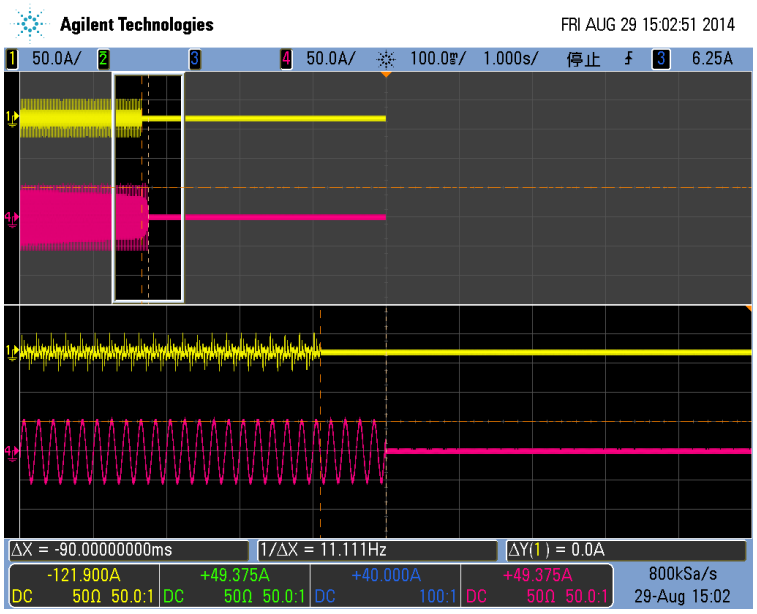
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 5%	50				
Reconnection time and power rise gradient after loss of mains	Same as above				
Iteration Phase L3-N	Power output level				
	100%				
Balance condition	P=8340W	Q_L=19080VA	Q_C=19150VA	$P_{Q.WR}$=67VA	Q=2,29
- 5%	248				

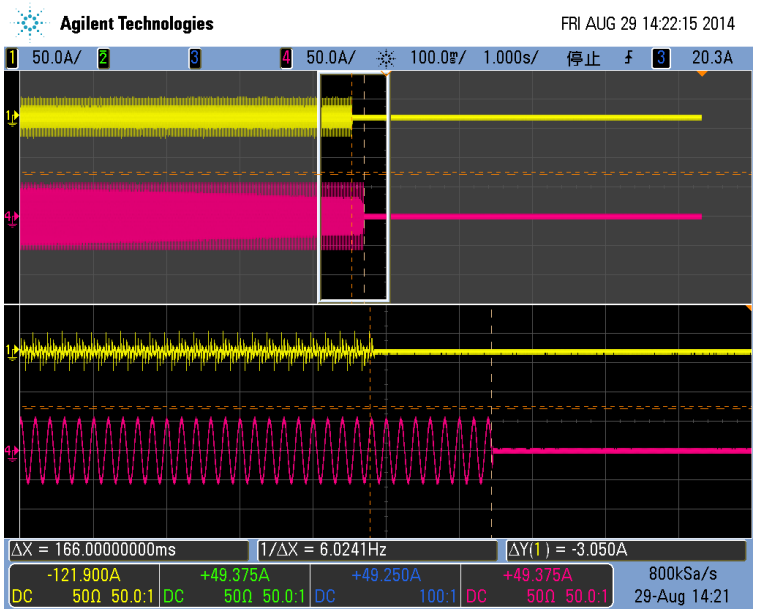
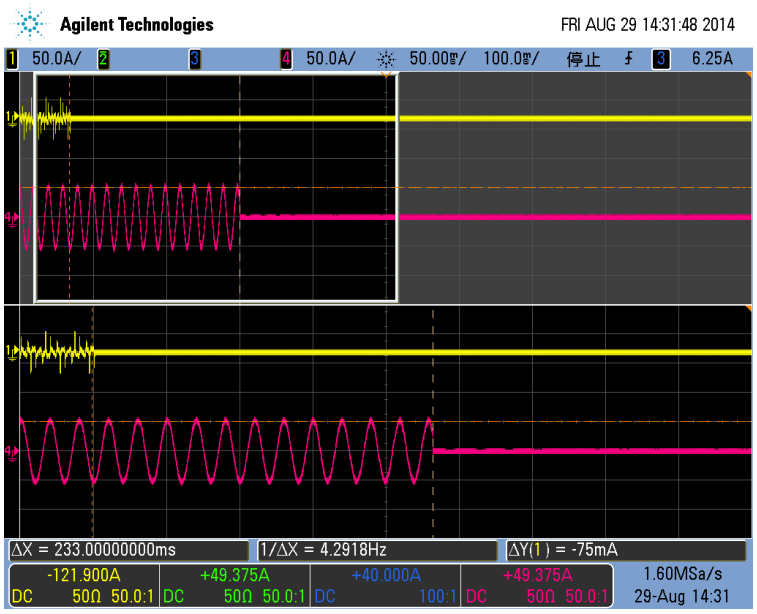
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 4%	116	
- 3%	92	

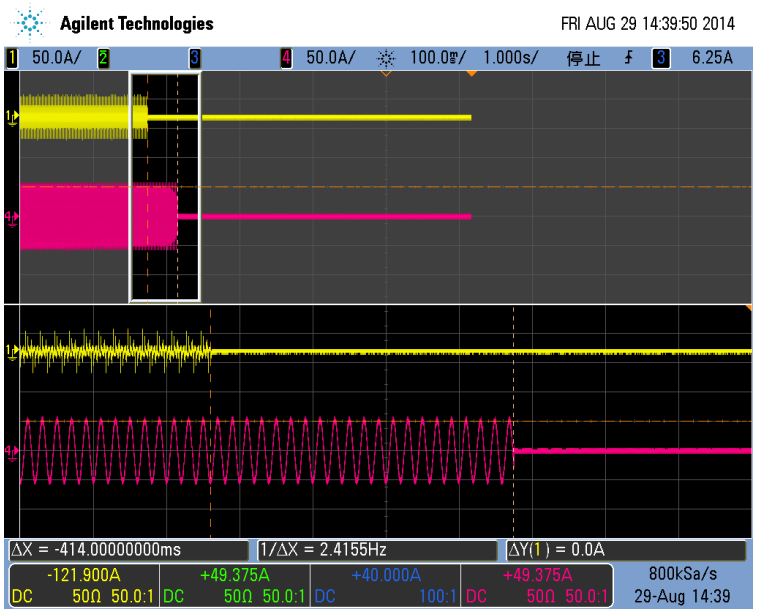
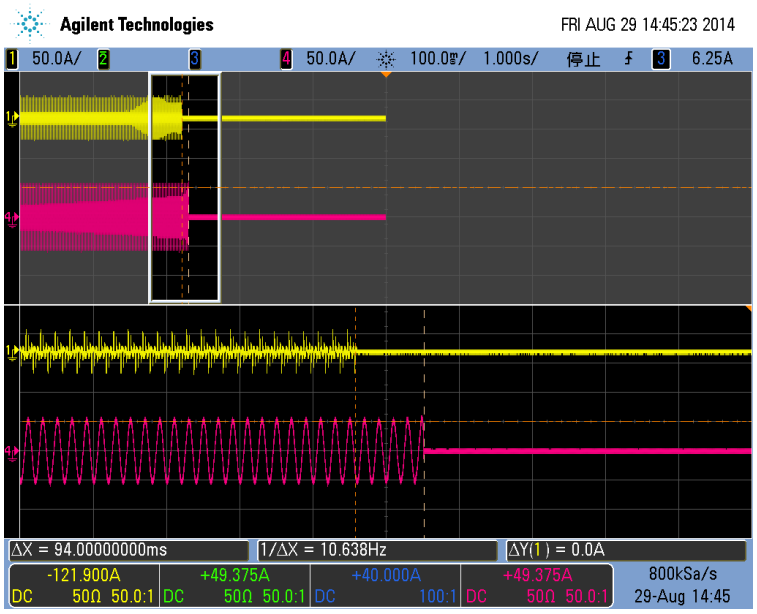
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 2%	60	
- 1%	90	

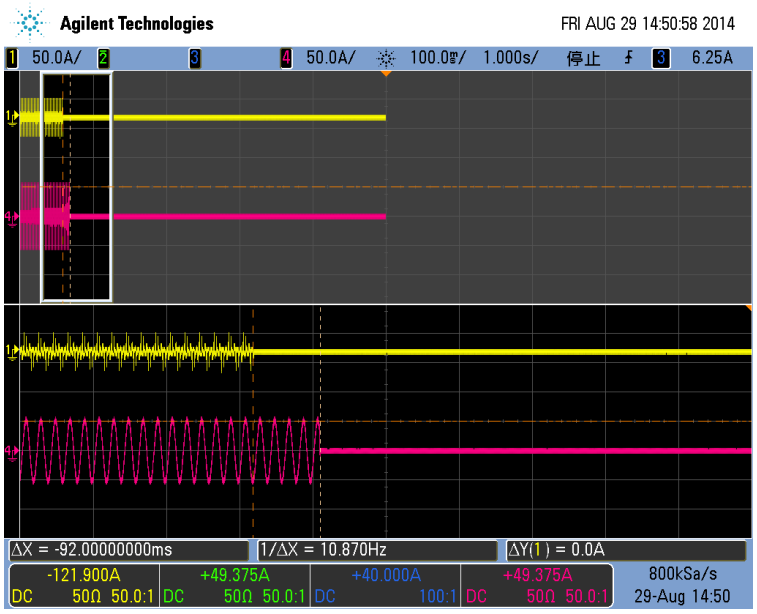
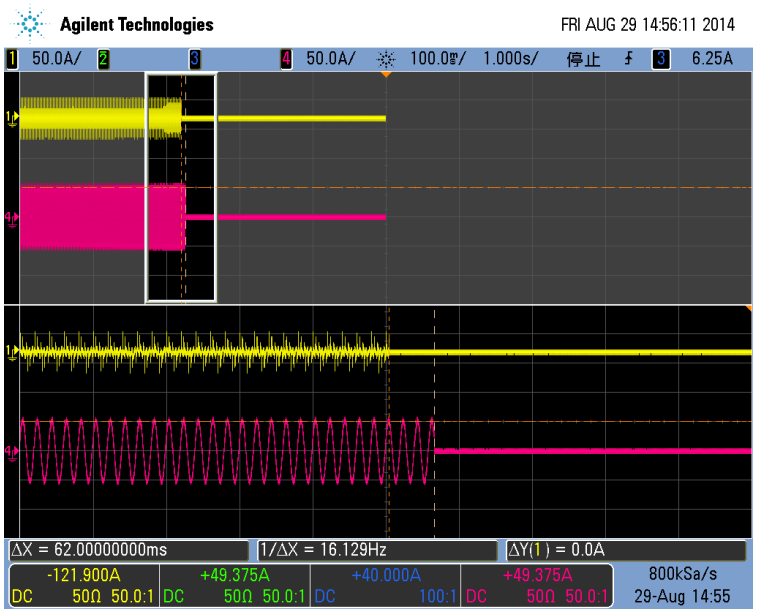
Clause	Requirement – Test	Measuring result – Remark	Verdict

0%	166	
+ 1%	233	

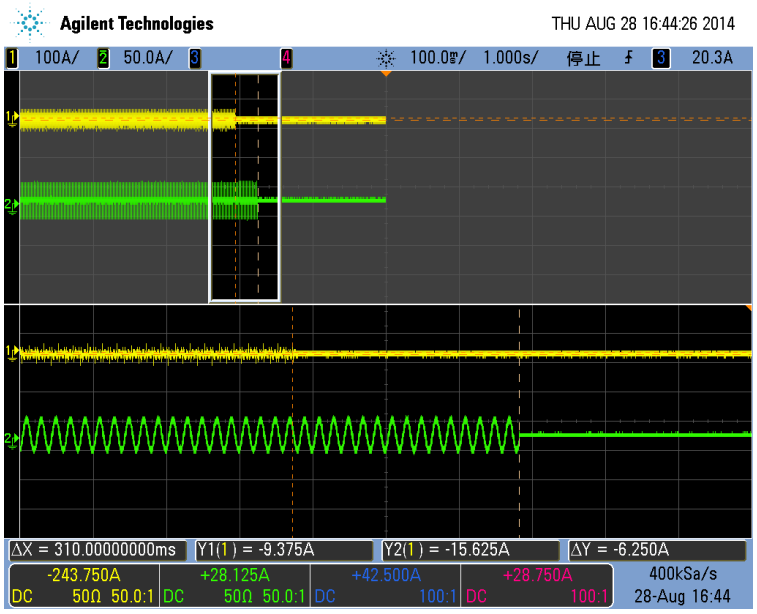
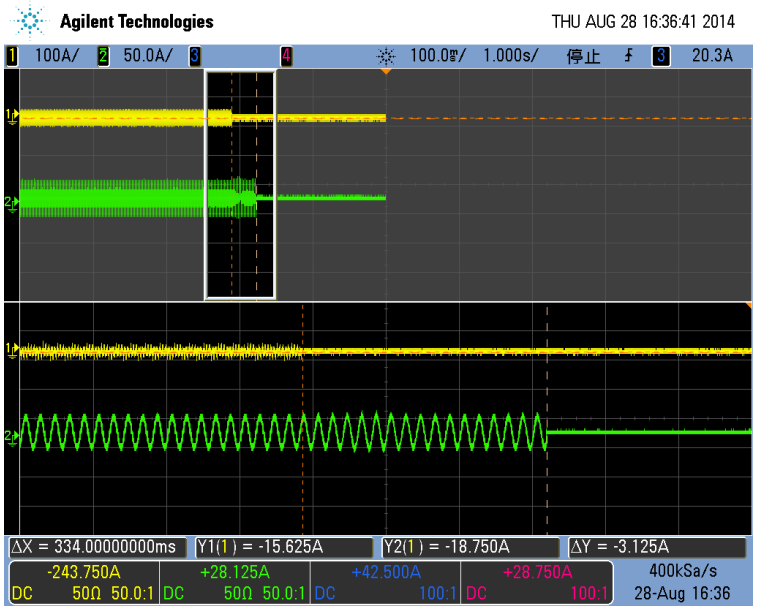
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 2%	414	
+ 3%	94	

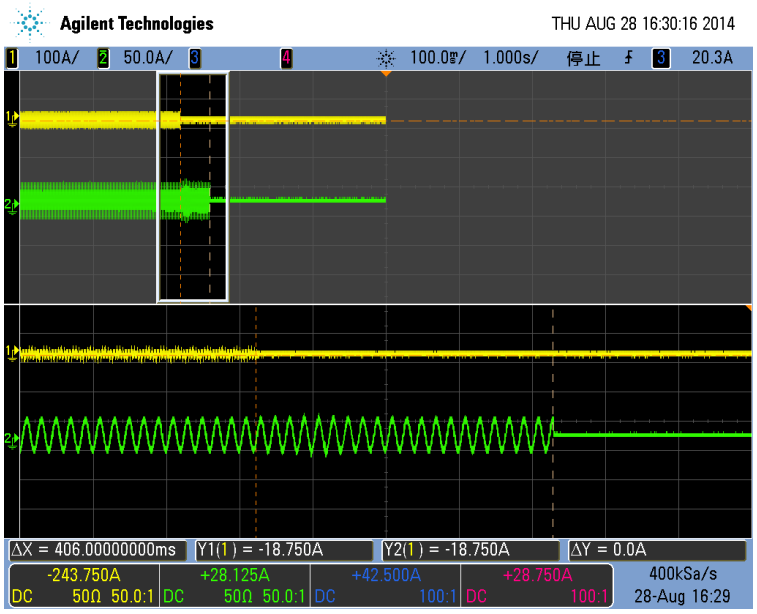
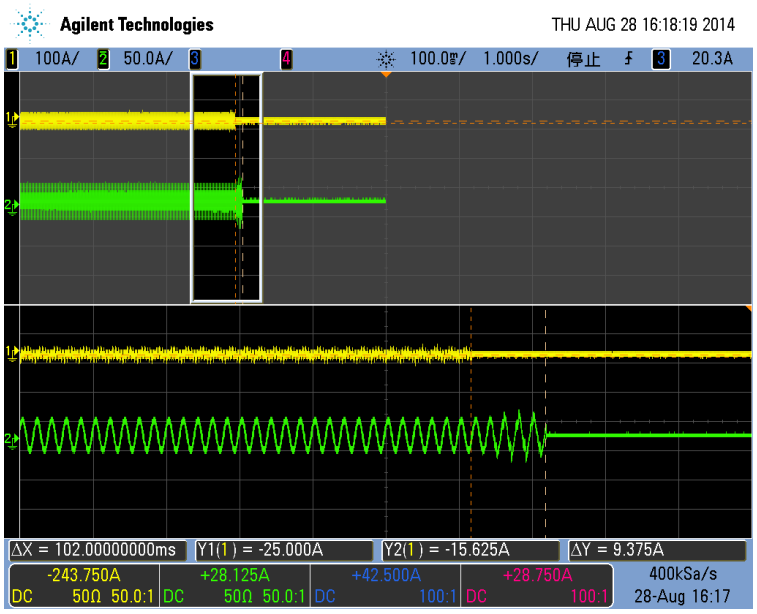
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 4%	92					
+ 5%	62					
Reconnection time and power rise gradient after loss of mains	Same as above					
Iteration Phase L1-N	Power output level 50%					
Balance condition	P=4170W	Q_L=9300VA	Q_C=9380VA	$P_{Q.WR}$=83VA	Q=2,24	

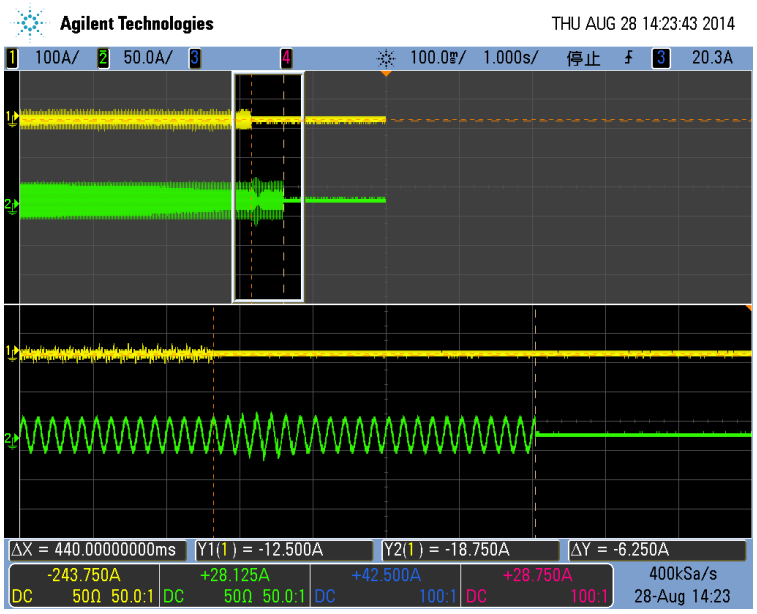
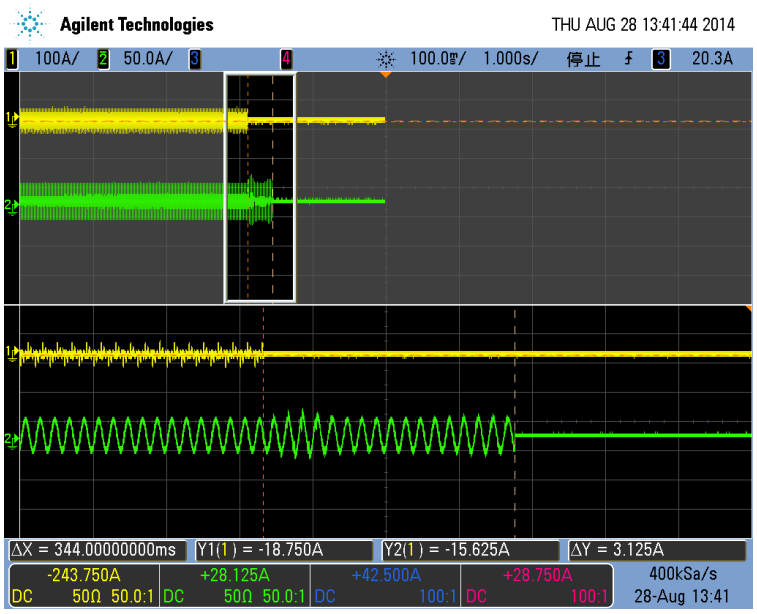
Clause	Requirement – Test	Measuring result – Remark	Verdict

Osc. parameter	Disconnecting time (ms)	Oscilloscope recorded waveforms
- 5%	310	
- 4%	334	

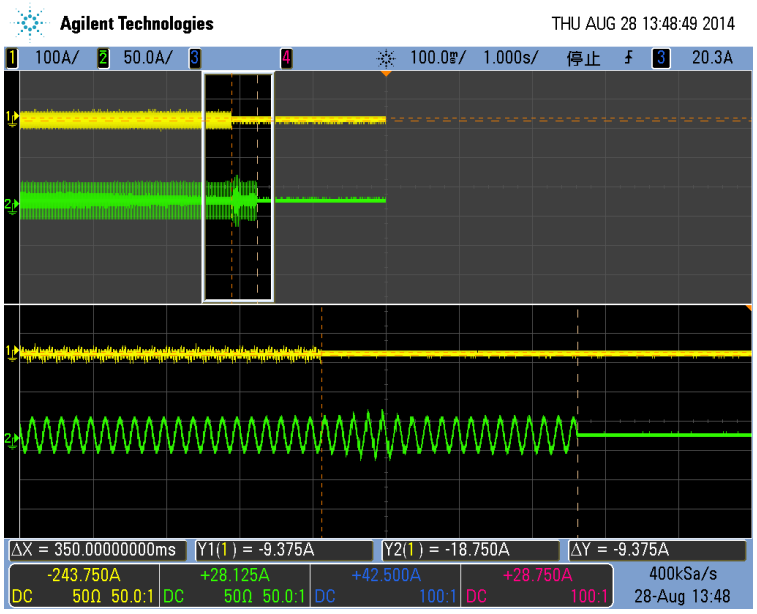
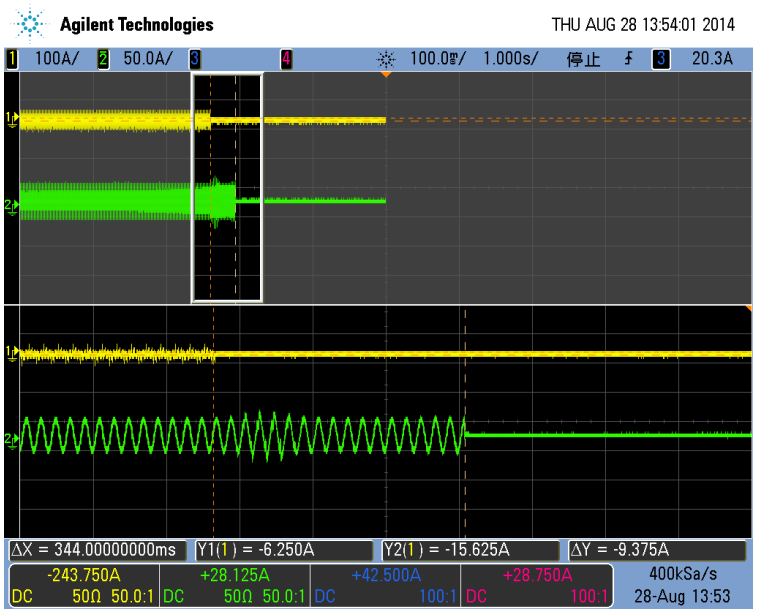
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 3%	406	
- 2%	102	

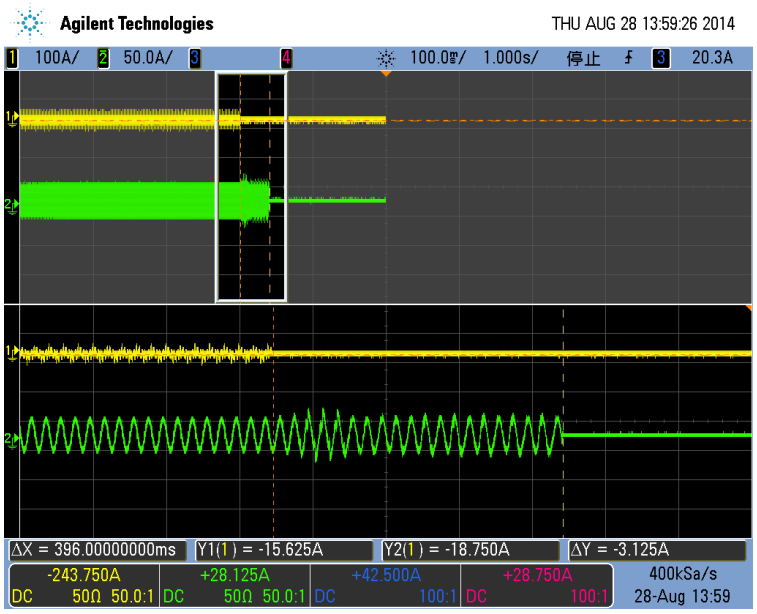
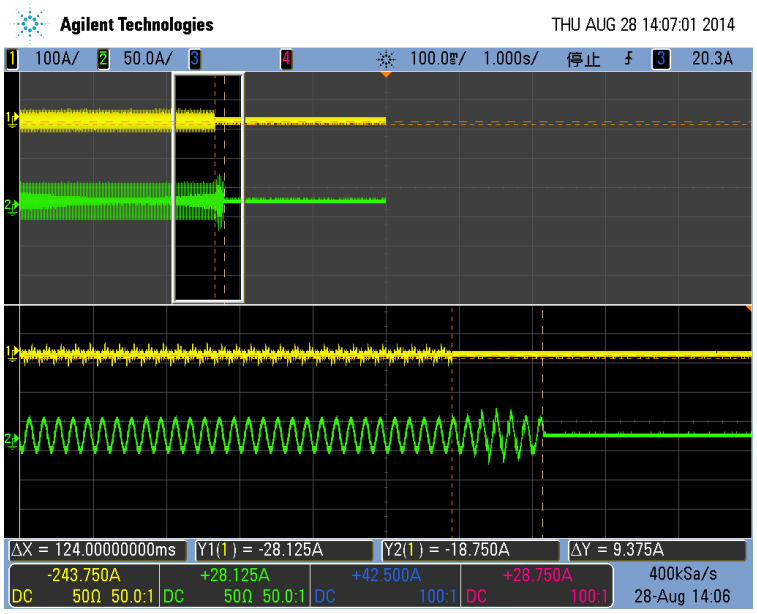
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 1%	440	
0%	344	

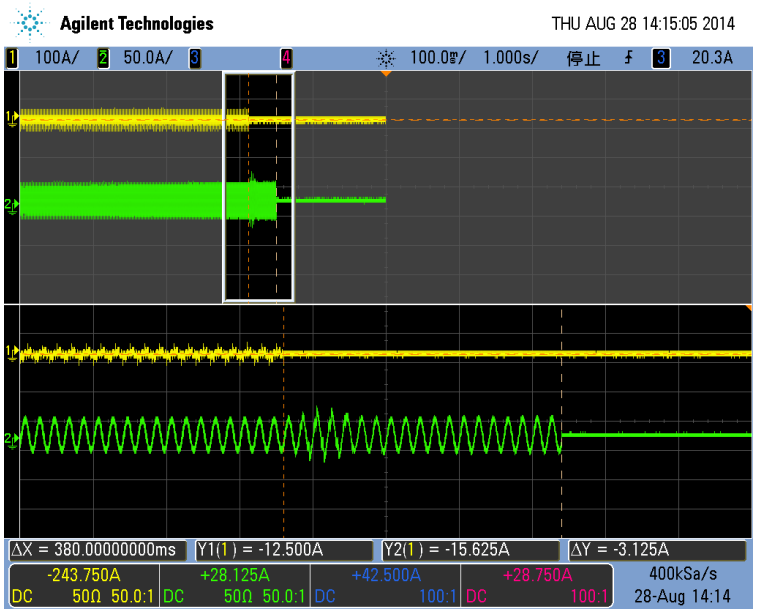
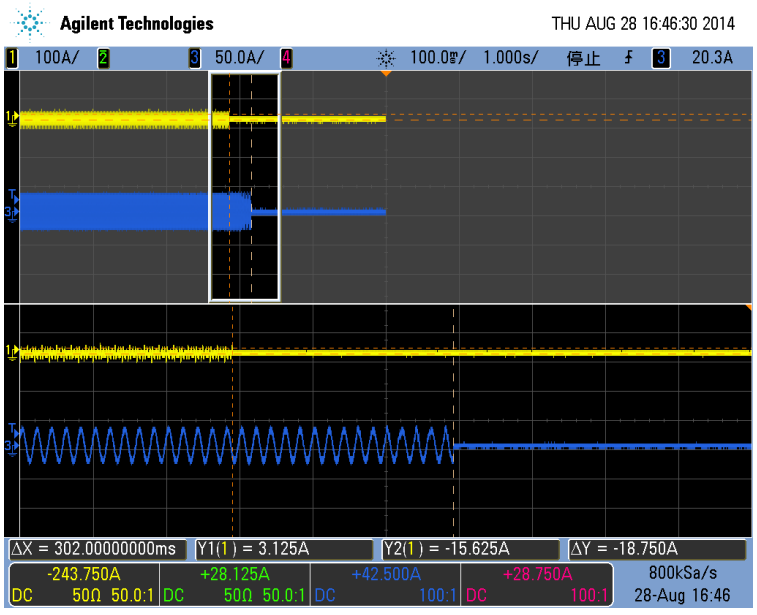
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 1%	350	
+ 2%	344	

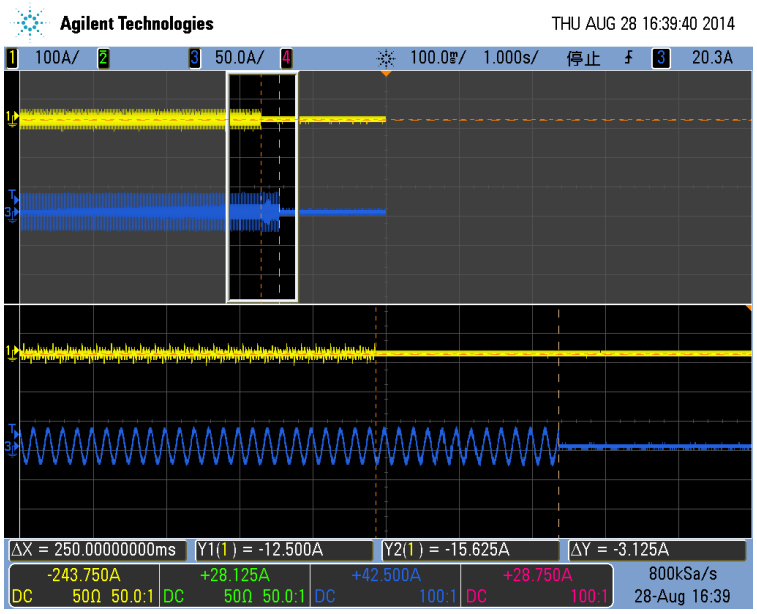
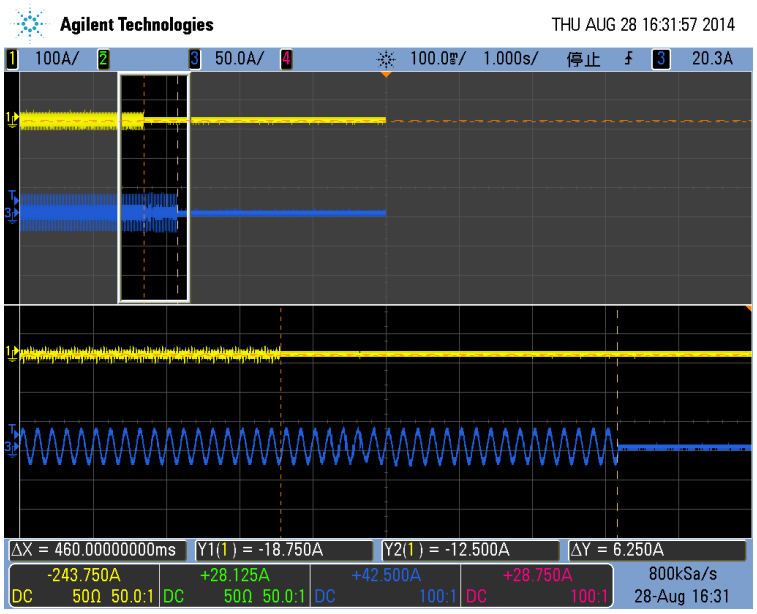
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 3%	396	
+ 4%	124	

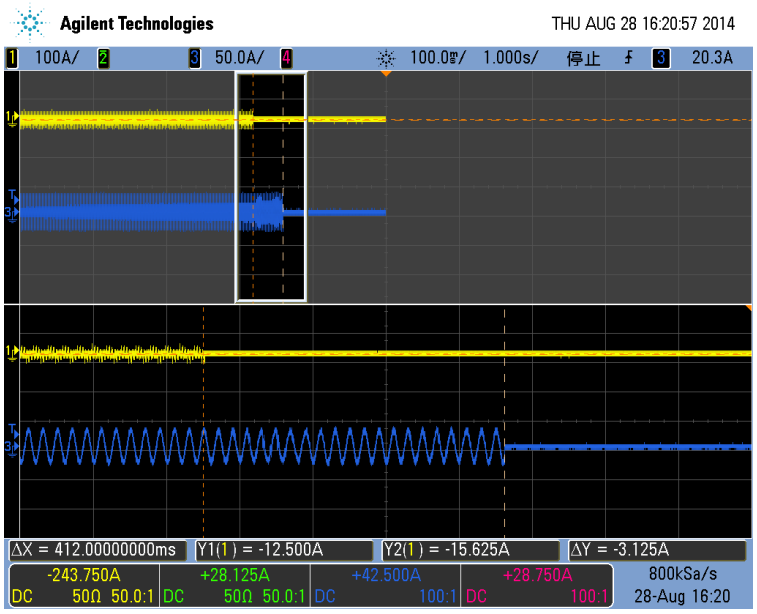
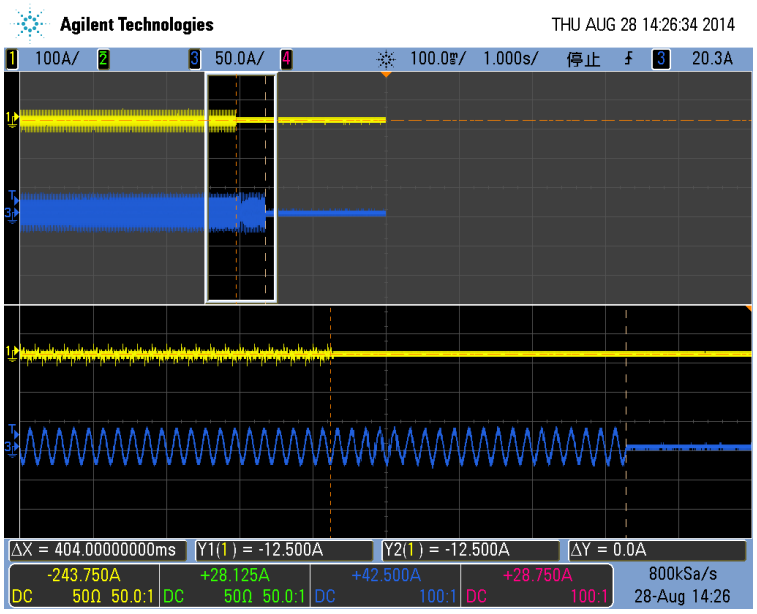
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 5%	380					
Iteration Phase L2-N	Power output level					
	50%					
Balance condition	P=4170W	Q_L=9290VA	Q_C=9380VA	$P_{Q.WR}$=83VA	Q=2,24	
- 5%	302					

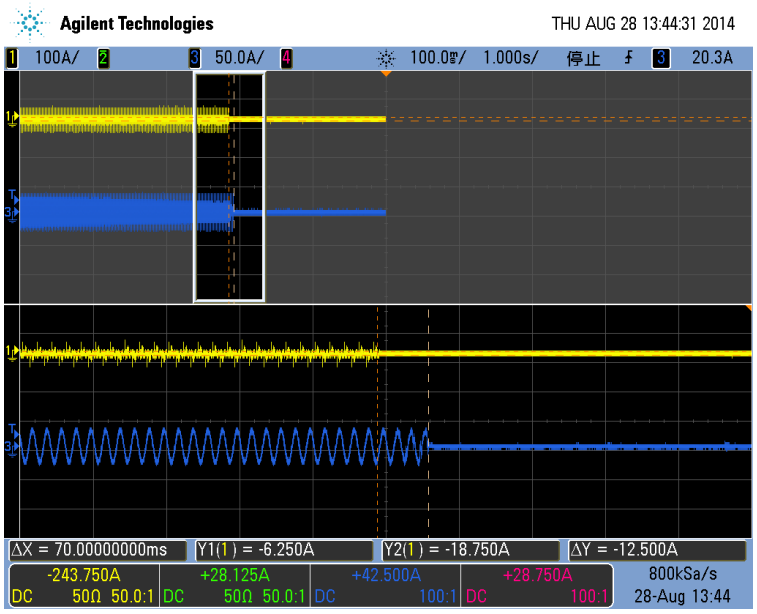
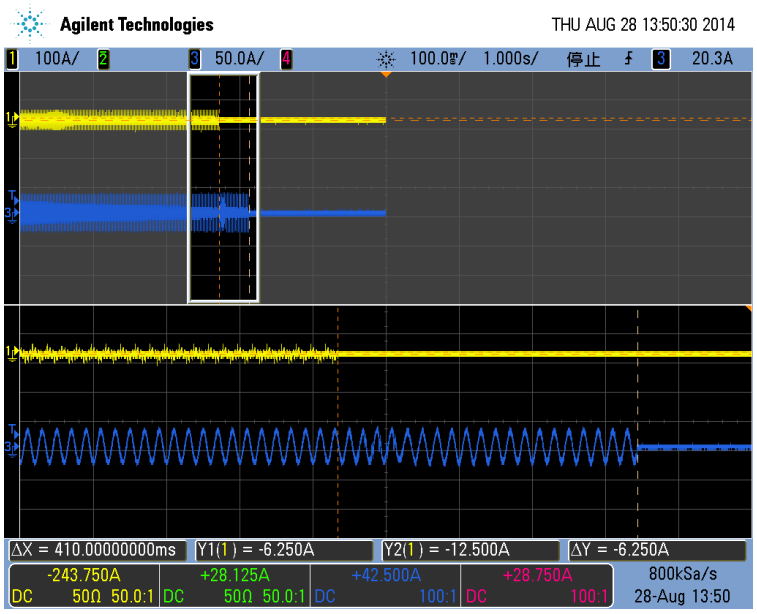
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 4%	250	
- 3%	460	

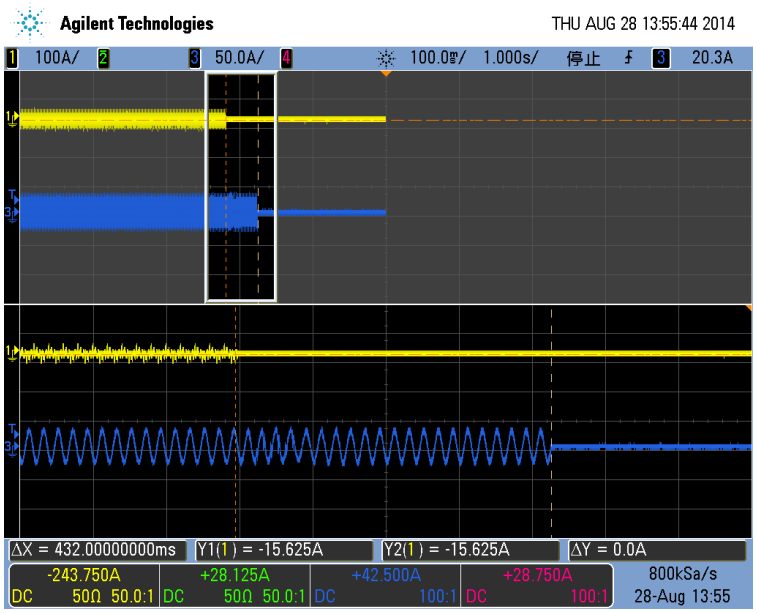
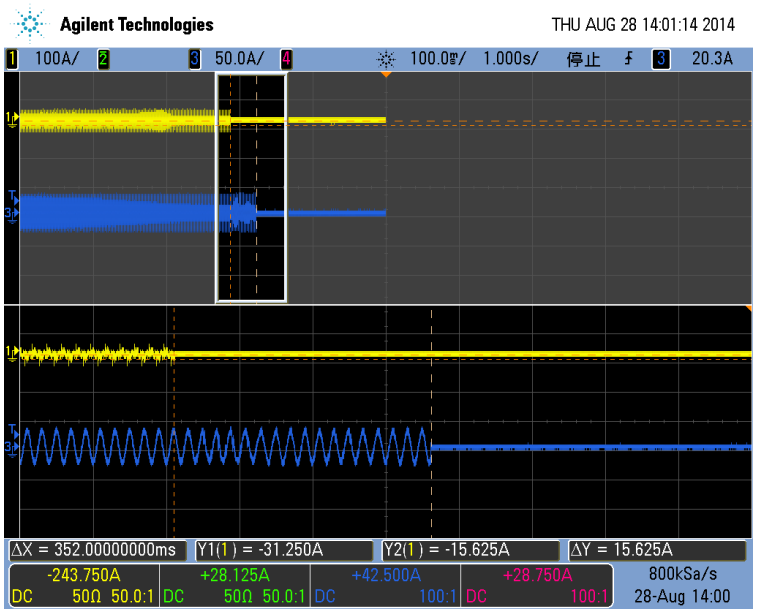
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 2%	412	
- 1%	404	

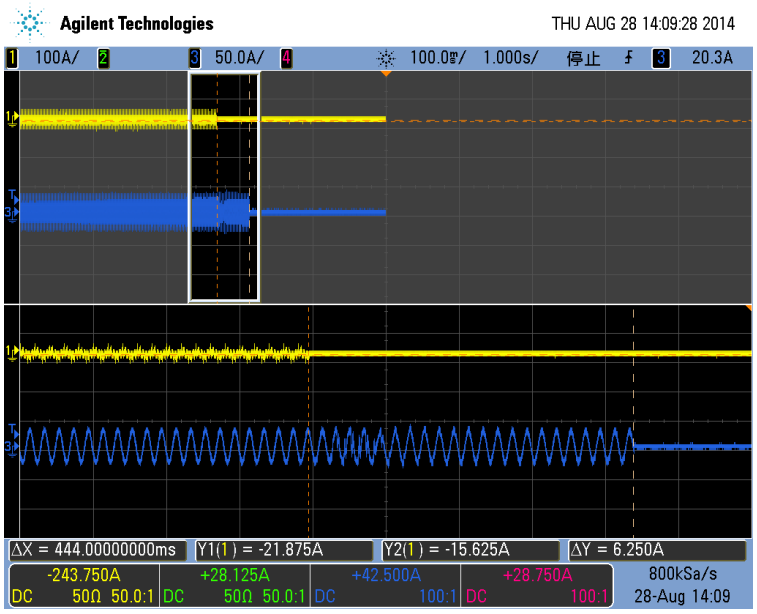
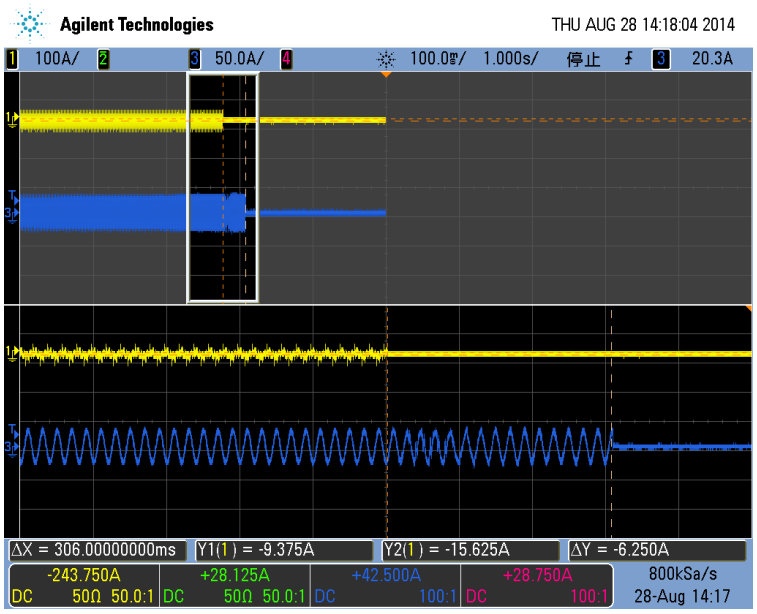
Clause	Requirement – Test	Measuring result – Remark	Verdict

0%	70	
+ 1%	410	

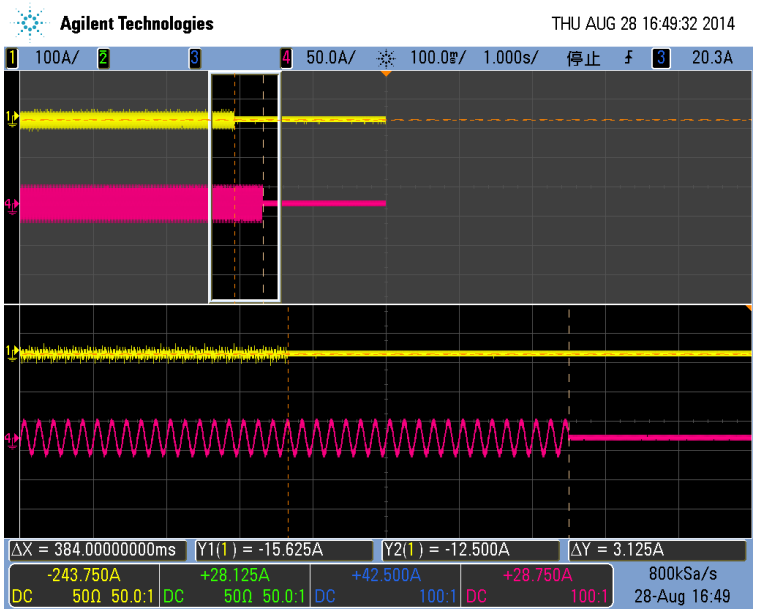
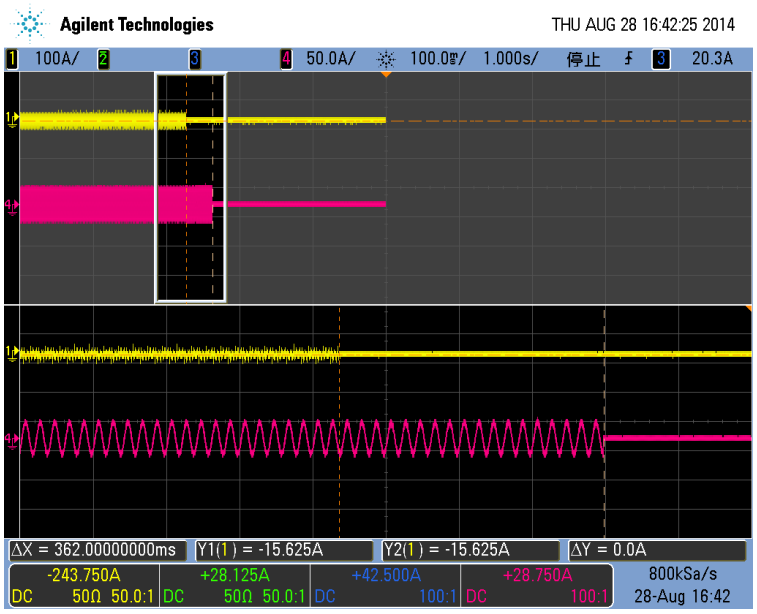
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 2%	432	
+ 3%	352	

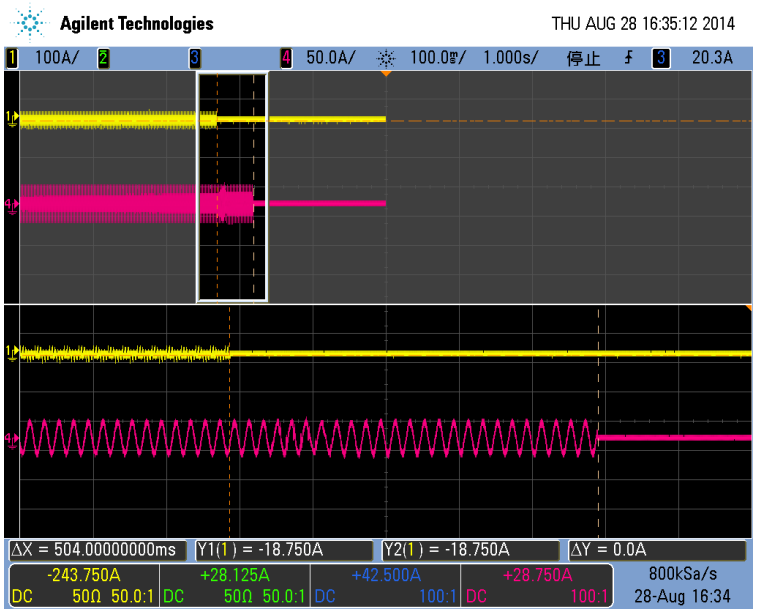
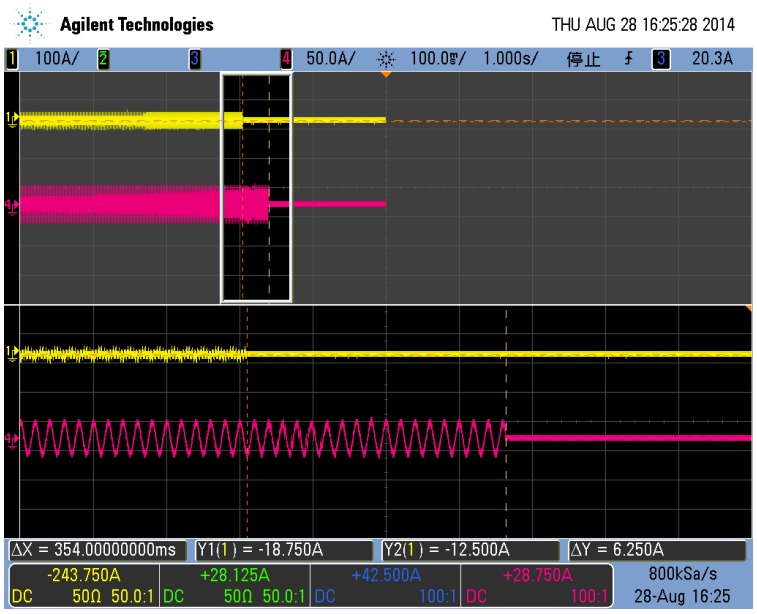
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 4%	444					
+ 5%	306					
Iteration Phase L3-N	Power output level 50%					
Balance condition	P=4170W	Q_L=9290VA	Q_C=9370VA	$P_{Q.WR}$=83VA	Q=2,24	

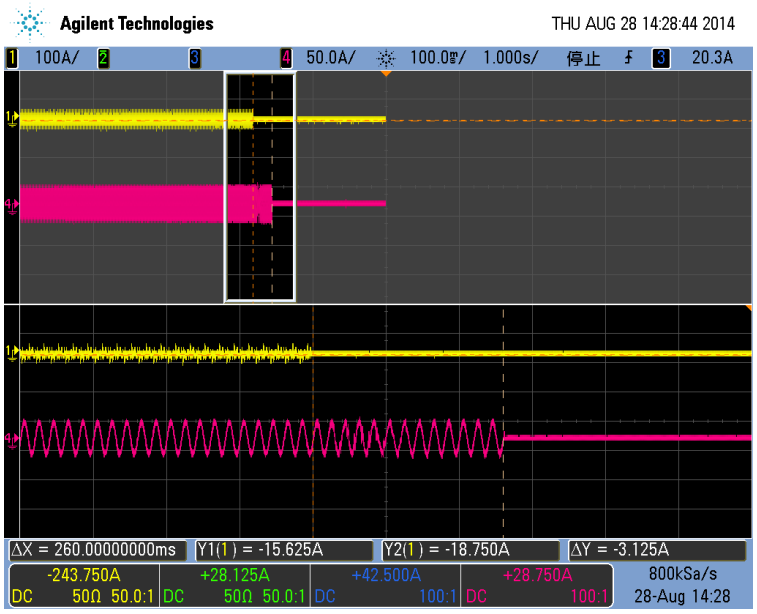
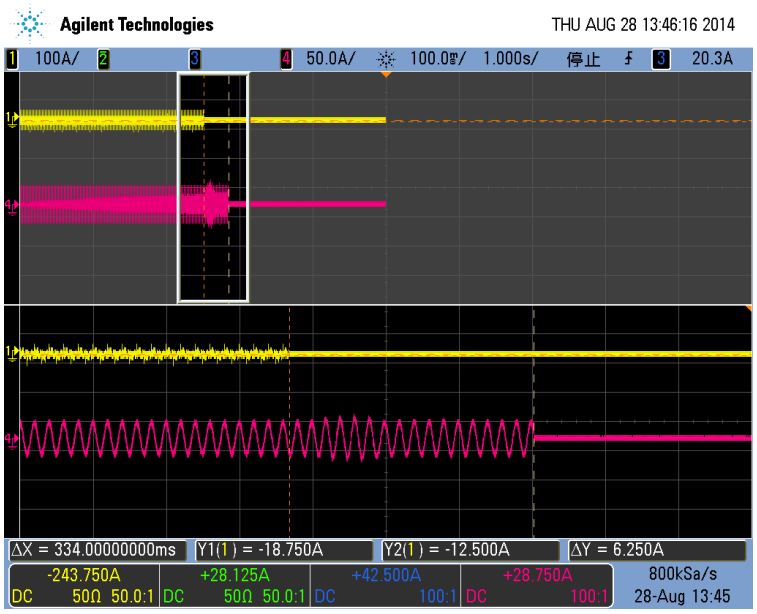
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 5%	384	
- 4%	362	

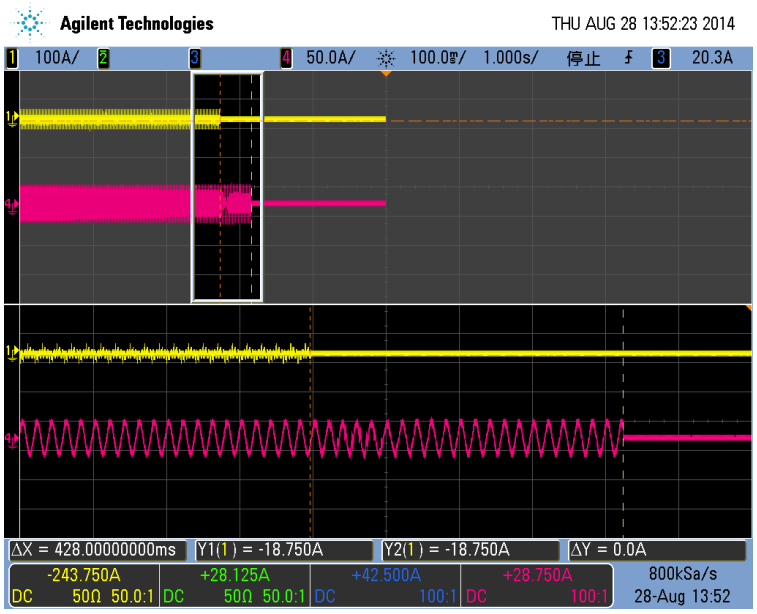
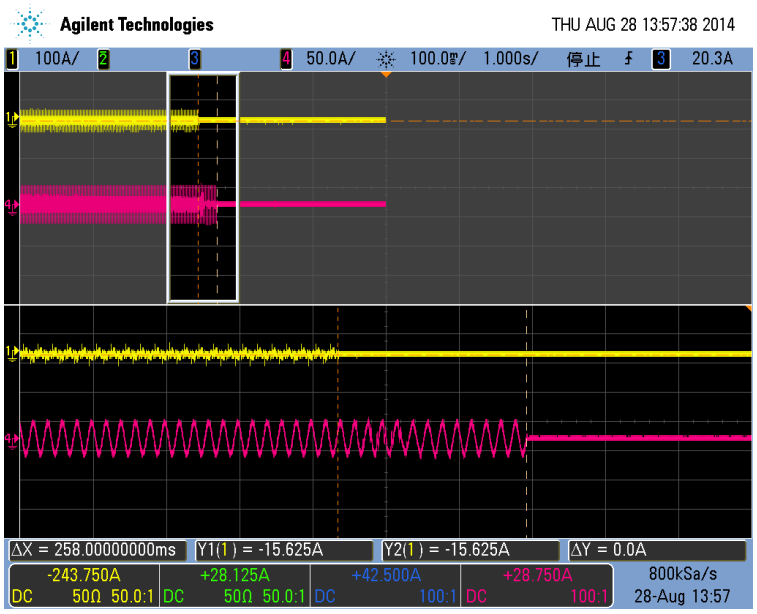
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 3%	504	
- 2%	354	

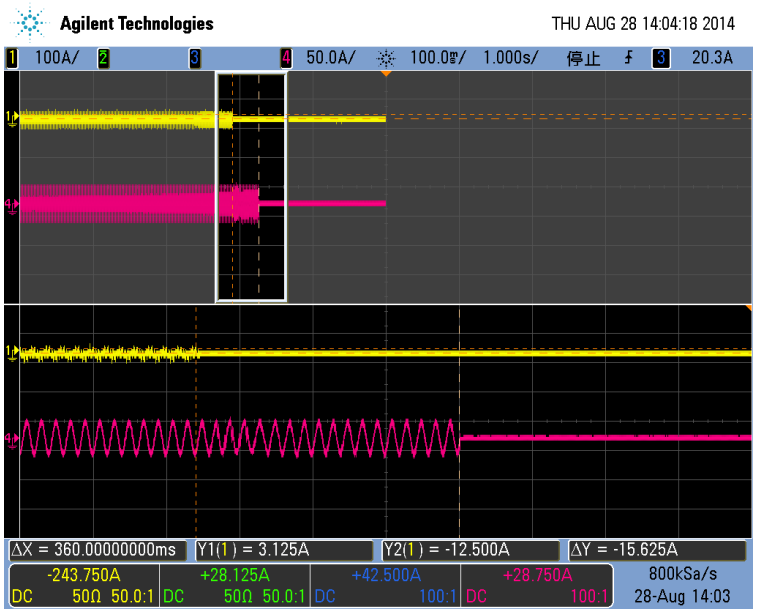
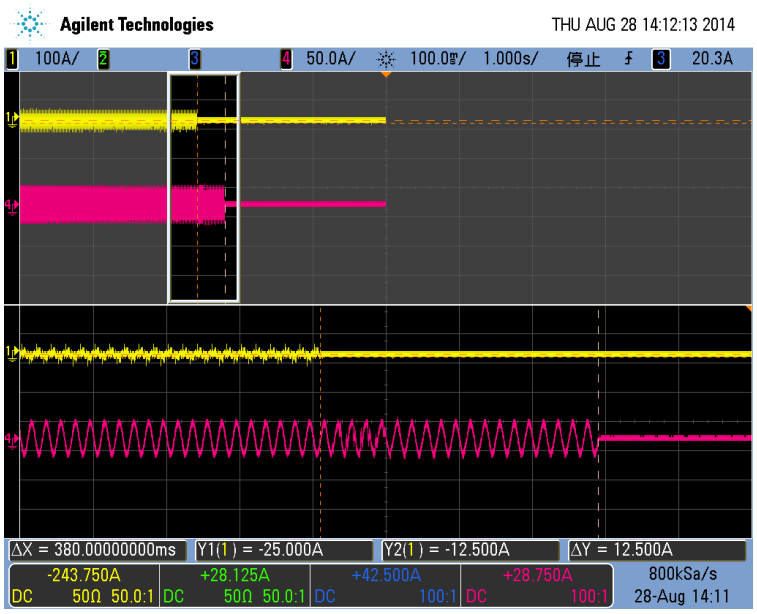
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 1%	260	
0%	334	

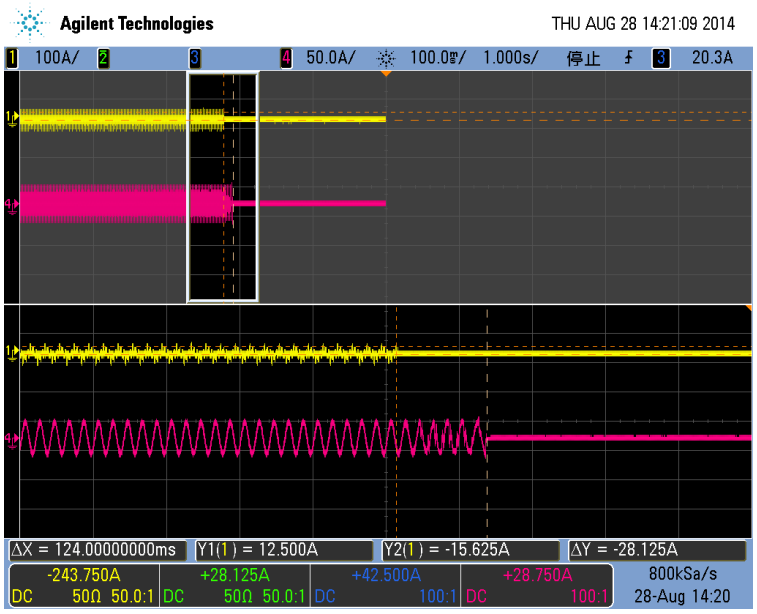
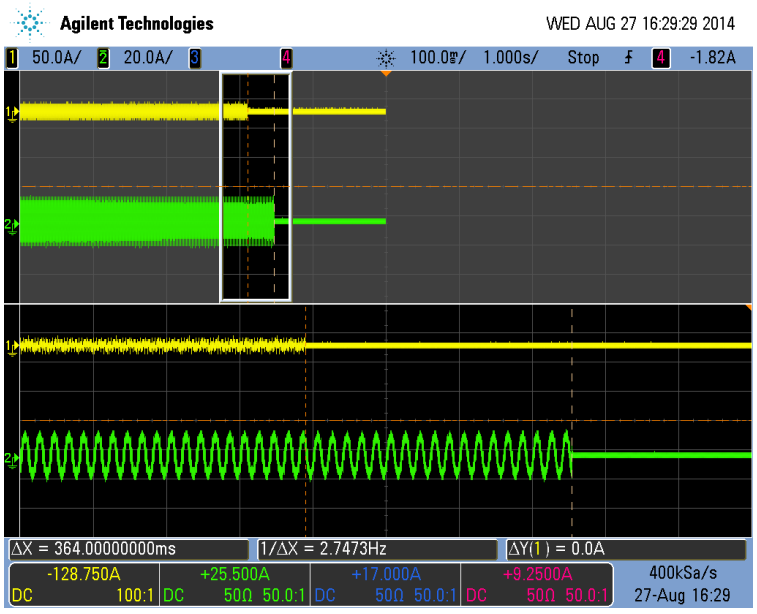
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 1%	428	
+ 2%	258	

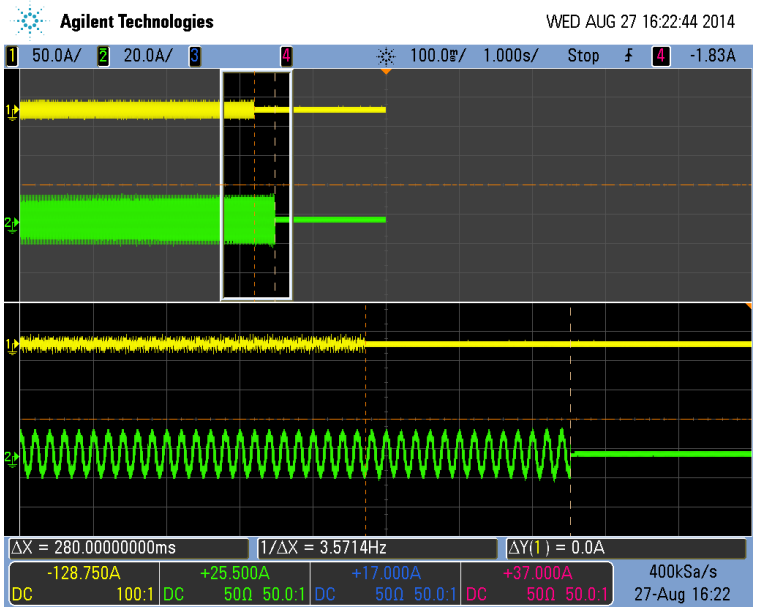
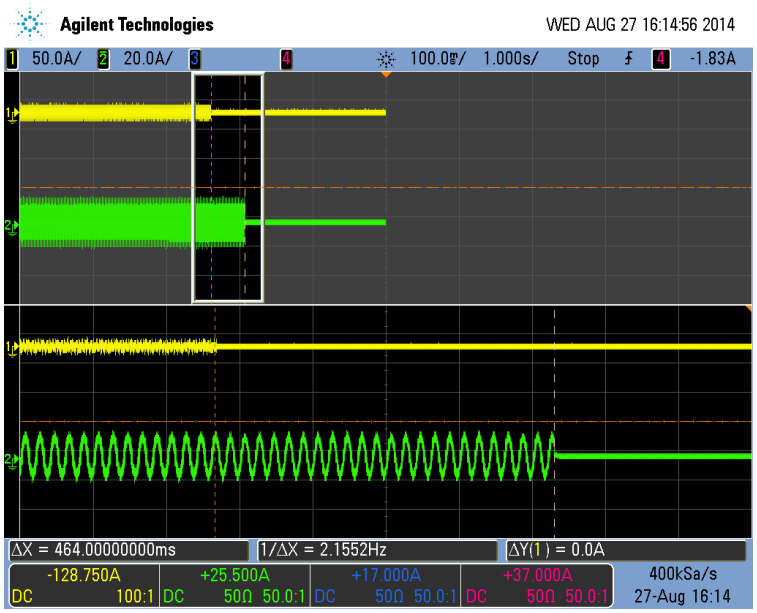
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 3%	360	
+ 4%	380	

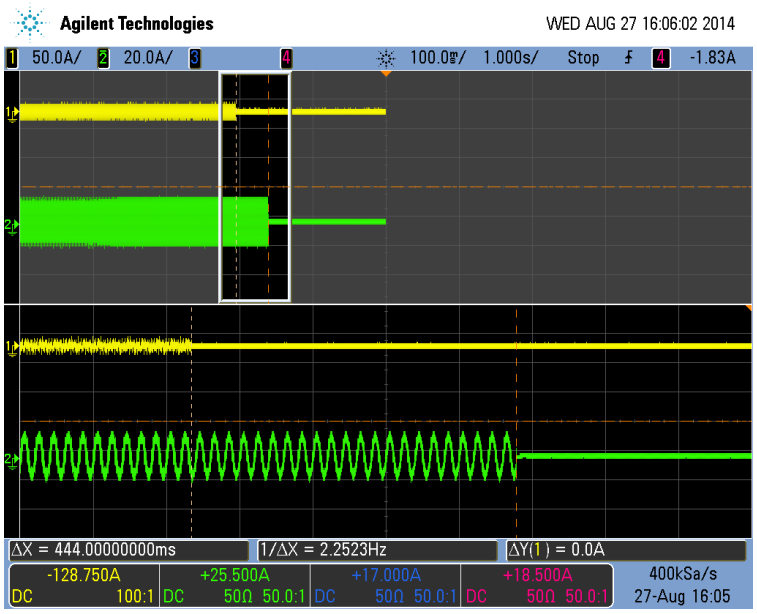
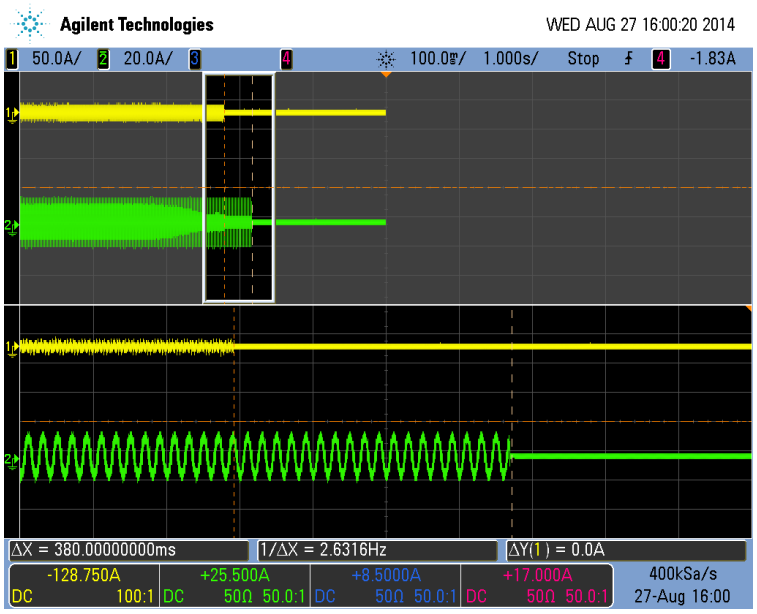
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 5%	124					
Iteration Phase L1-N	Power output level					
	25%					
Balance condition	P=2090W	Q_L=4510VA	Q_C=4620VA	$P_{Q.WR}$=104VA	Q=2,19	
Osc. parameter	Disconnecting time (ms)	Oscilloscope recorded waveforms				
- 5%	364					

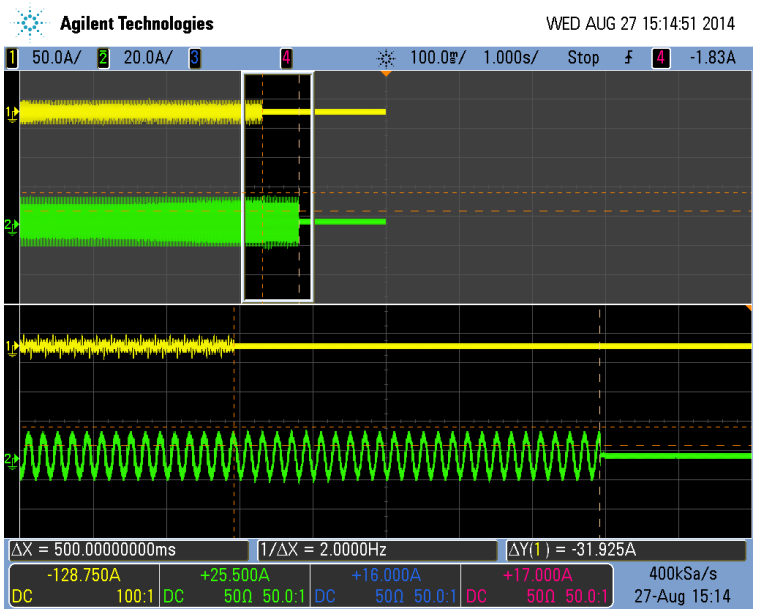
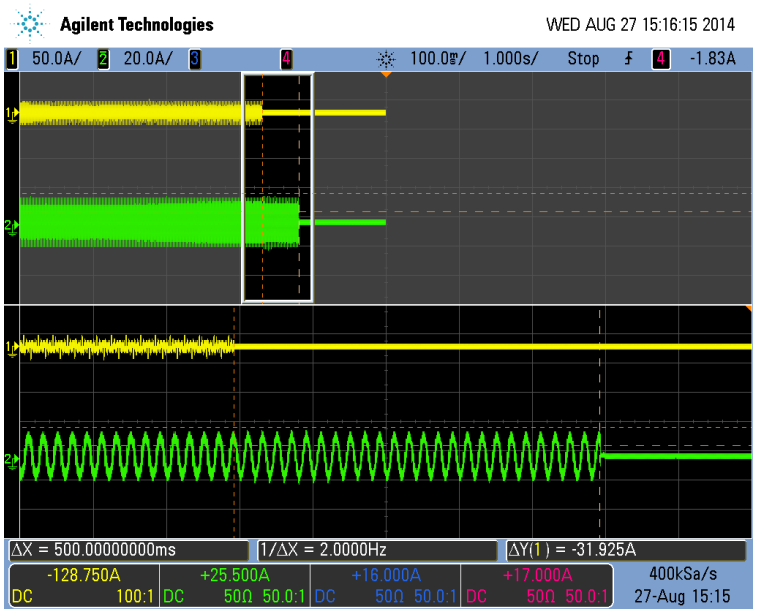
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 4%	280	
- 3%	464	

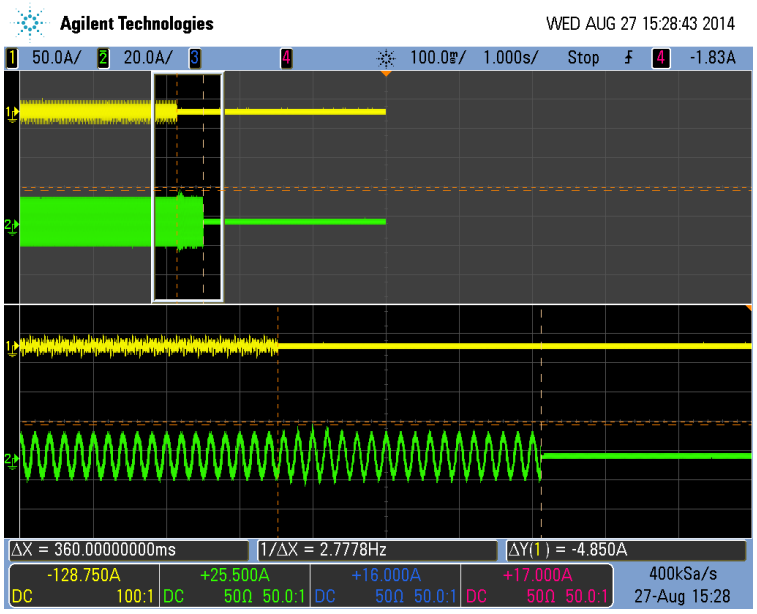
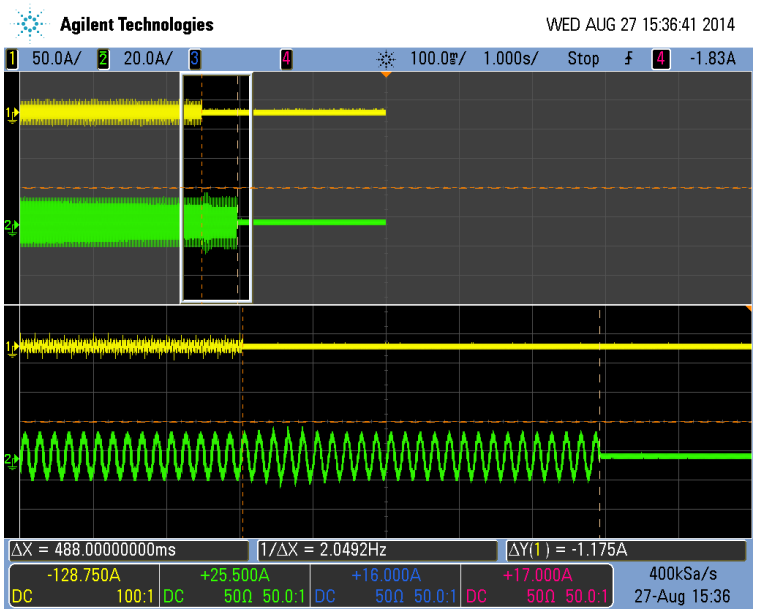
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 2%	444	
- 1%	380	

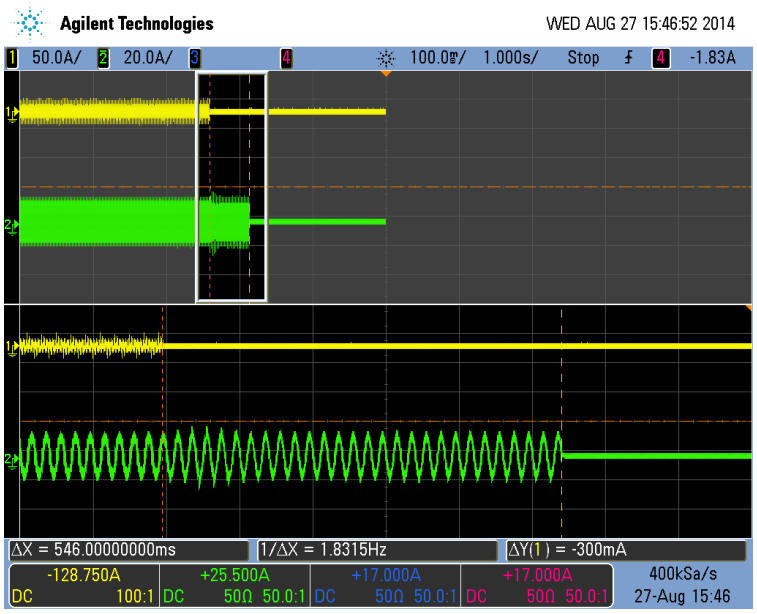
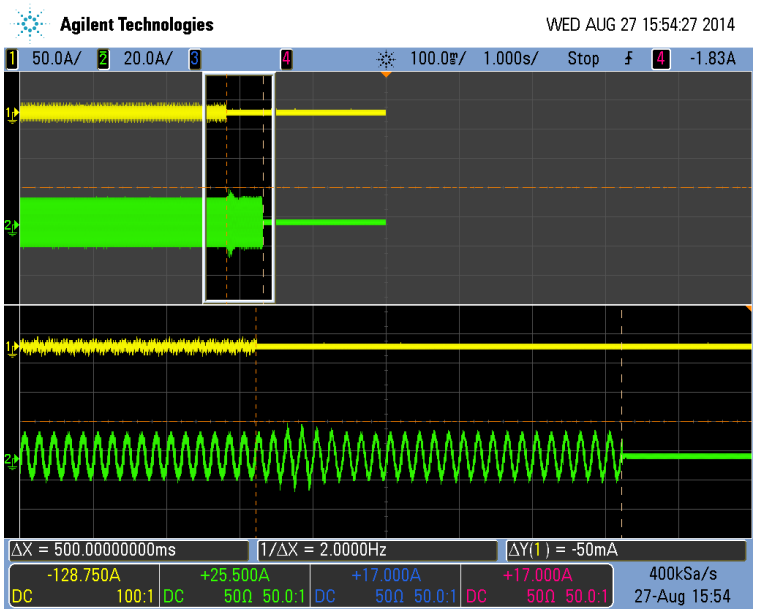
Clause	Requirement – Test	Measuring result – Remark	Verdict

0%	500	
+ 1%	500	

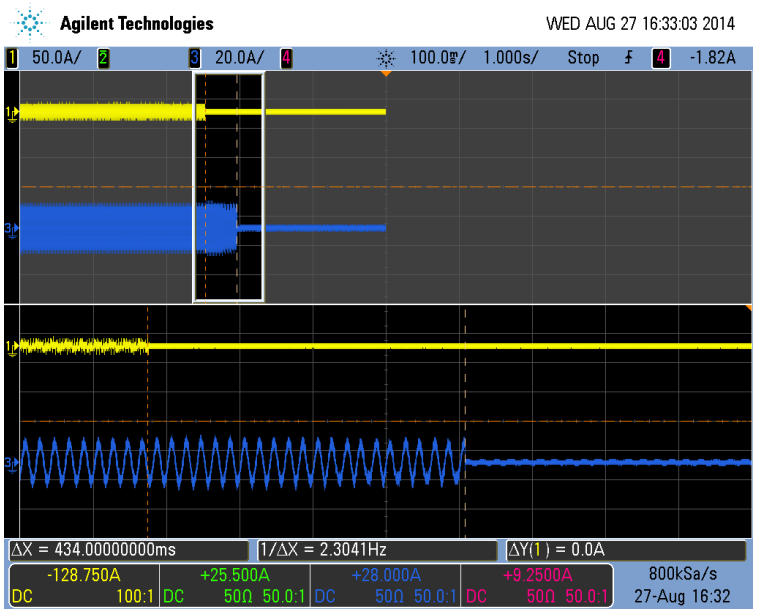
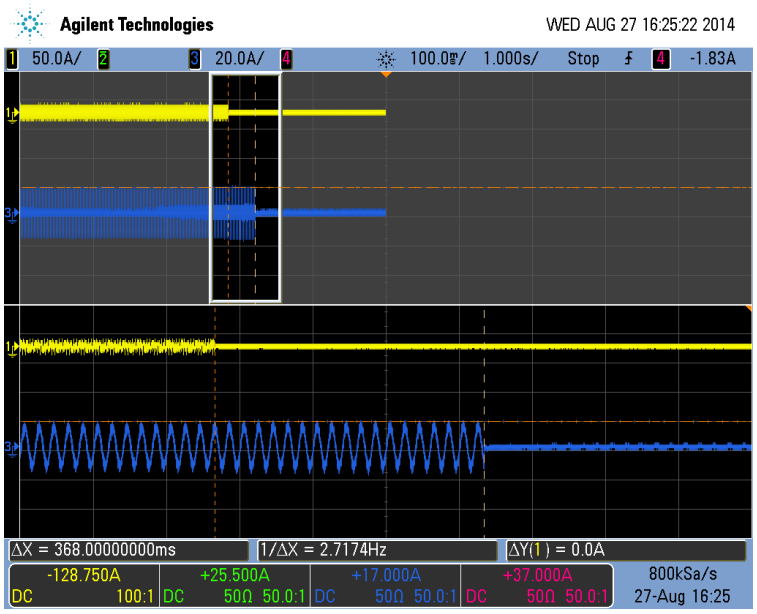
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 2%	360	
+ 3%	488	

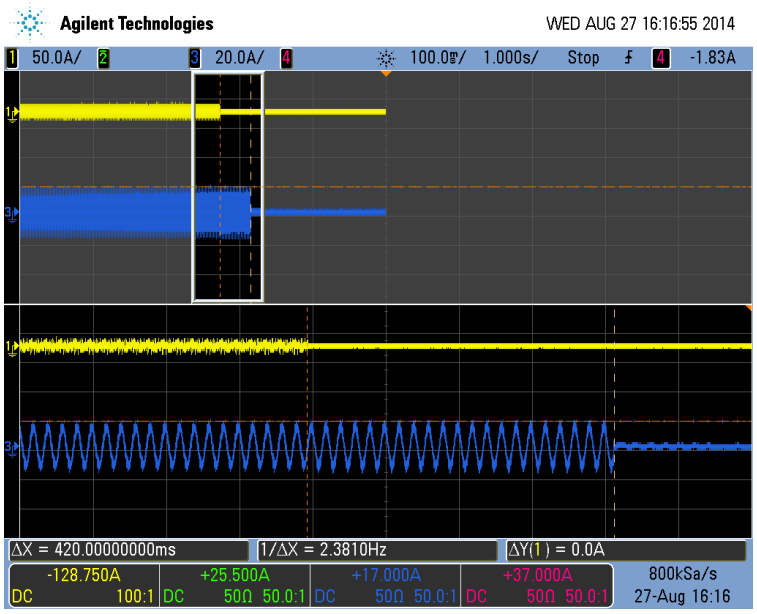
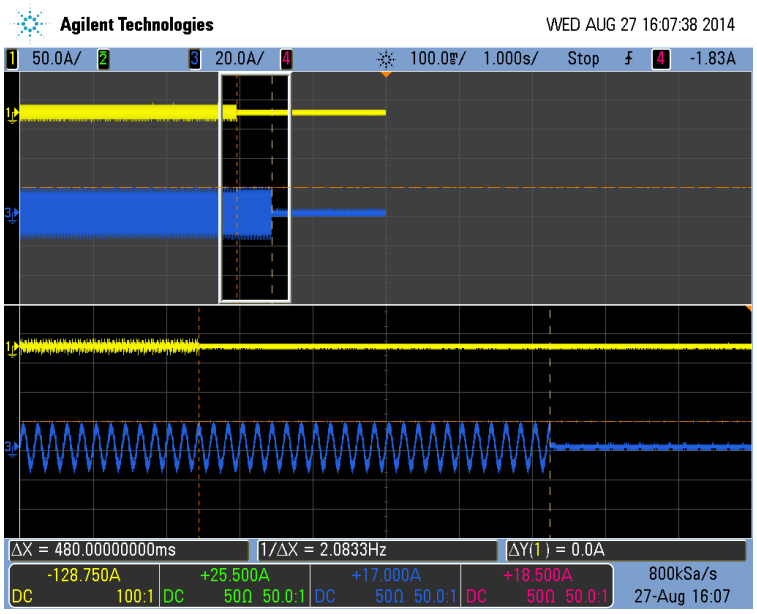
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 4%	546					
+ 5%	500					
Iteration Phase L2-N	Power output level 25%					
Balance condition	P=2090W	Q_L=4520VA	Q_C=4620VA	$P_{Q.WR}$=104VA	Q=2,19	

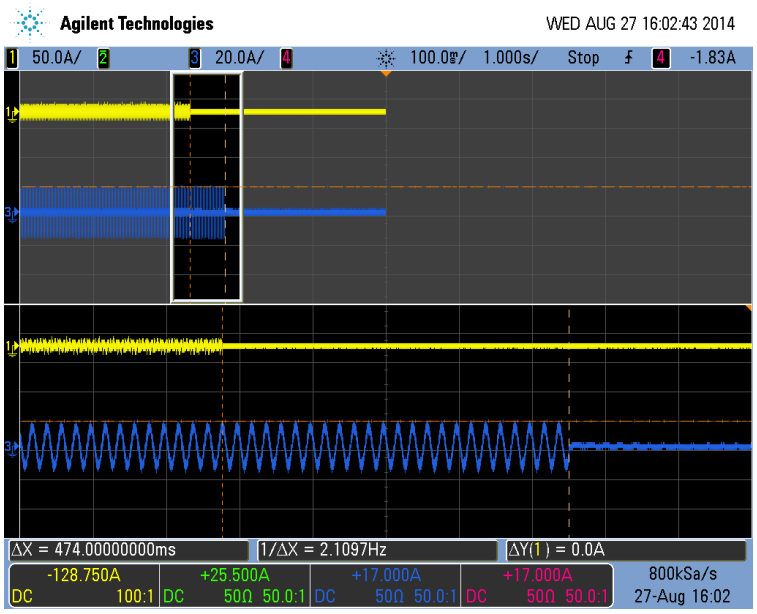
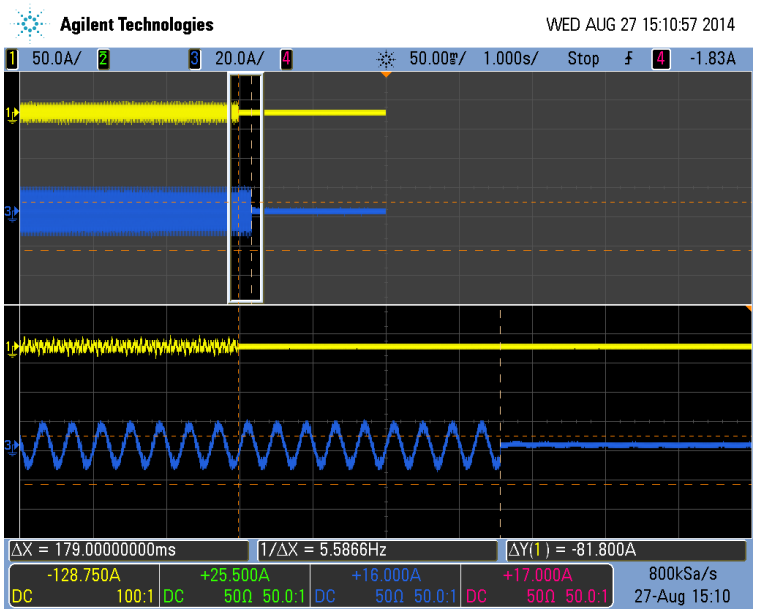
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 5%	434	
- 4%	368	

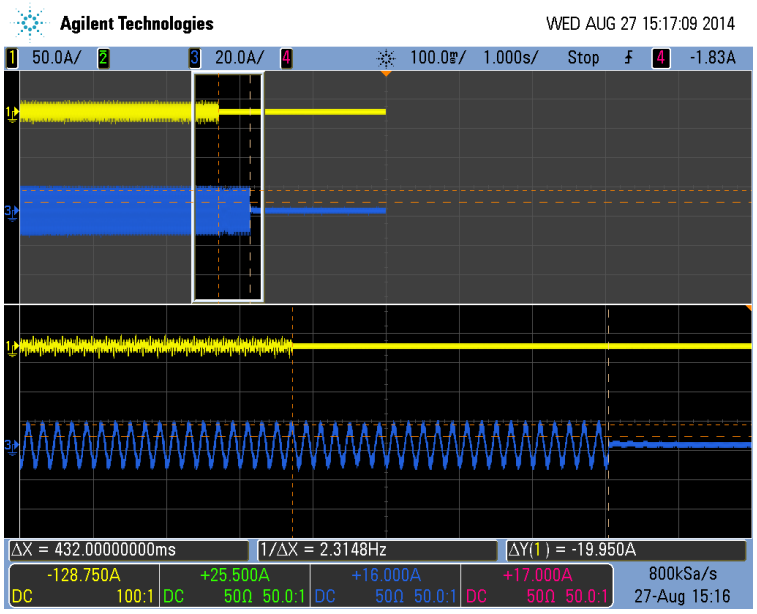
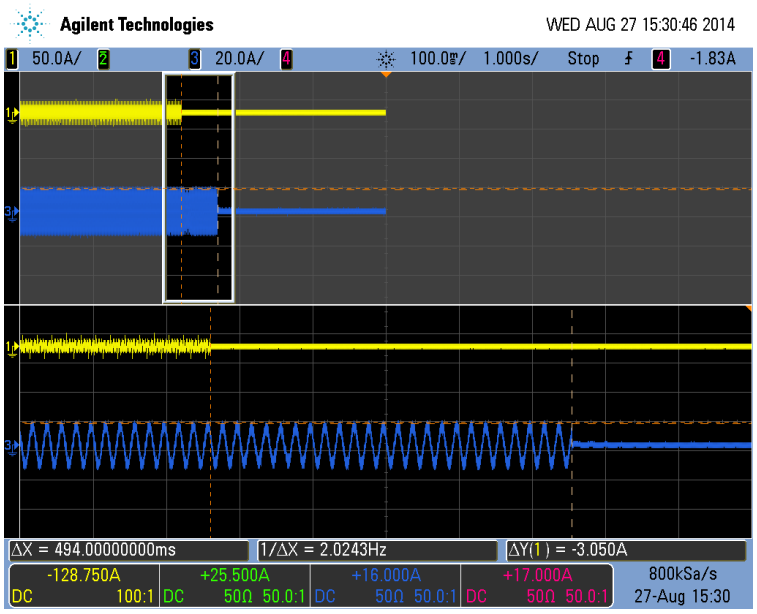
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 3%	420	
- 2%	480	

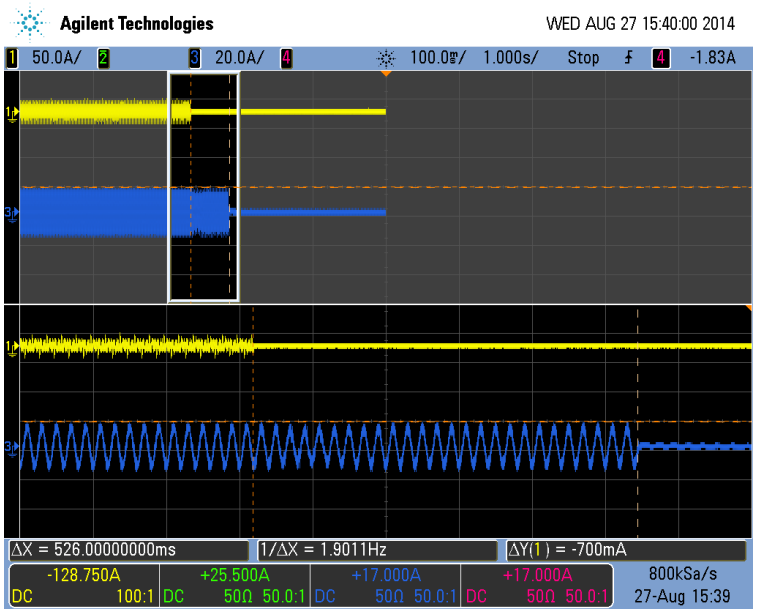
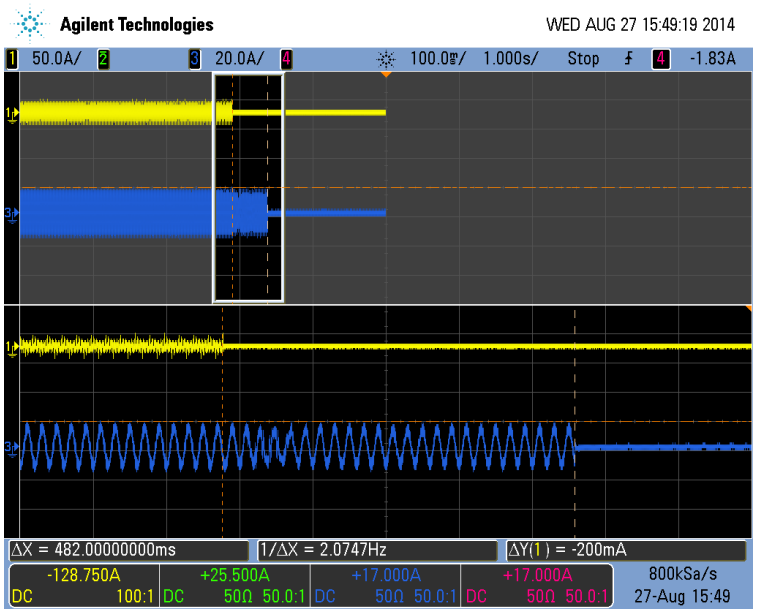
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 1%	474	
0%	179	

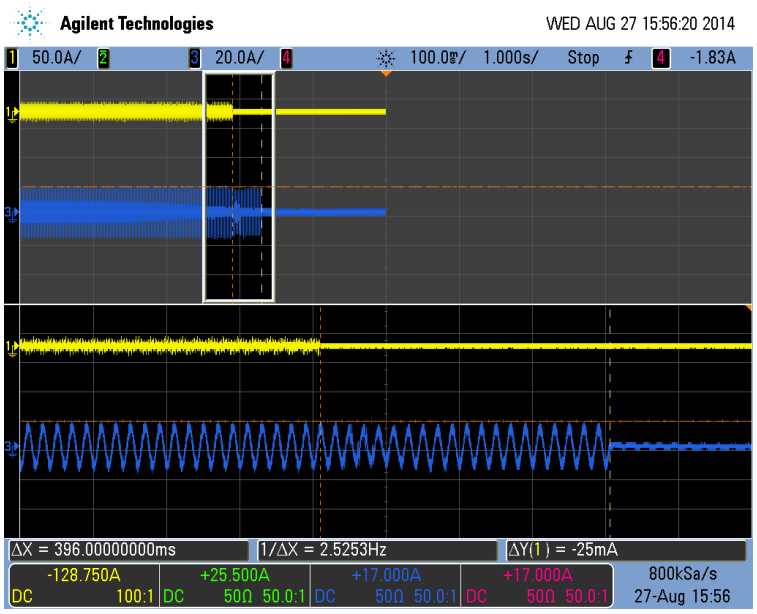
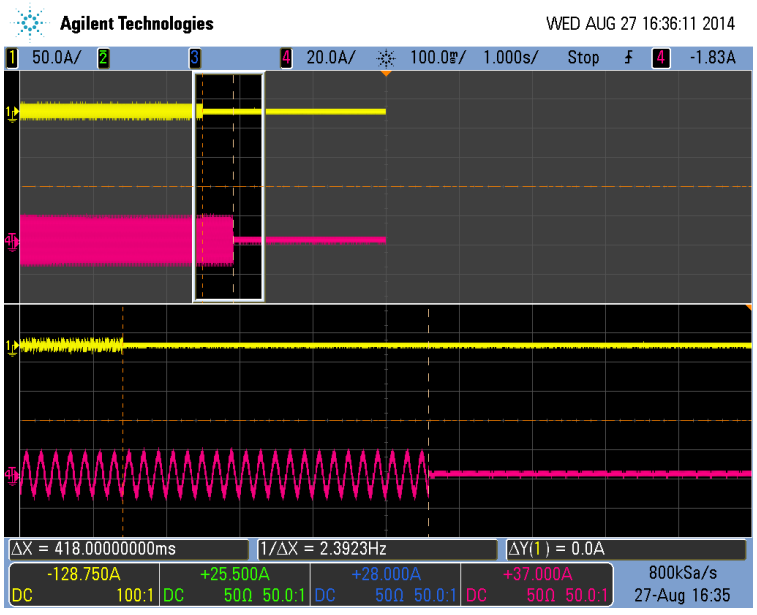
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 1%	432	
+ 2%	494	

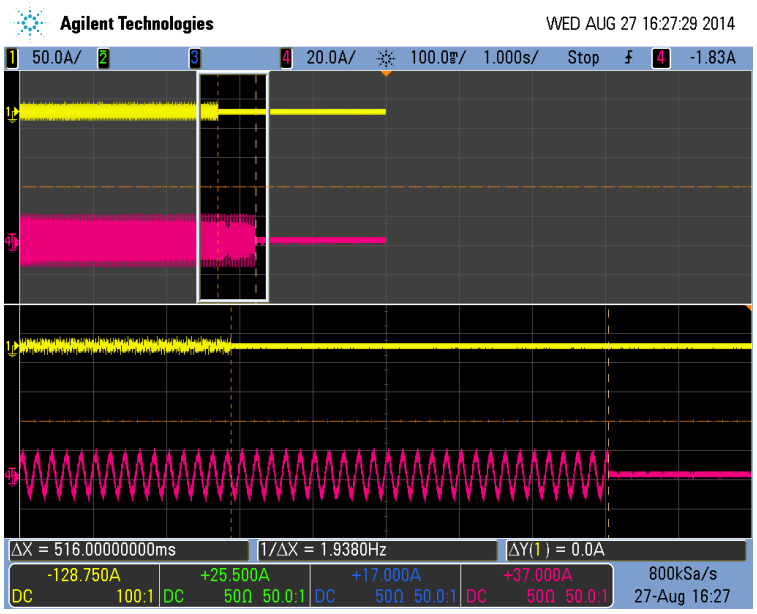
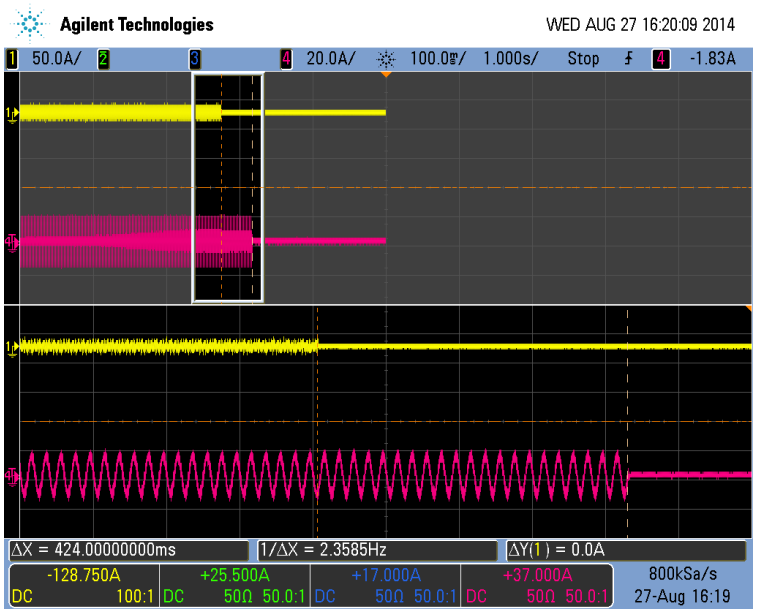
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 3%	526	
+ 4%	482	

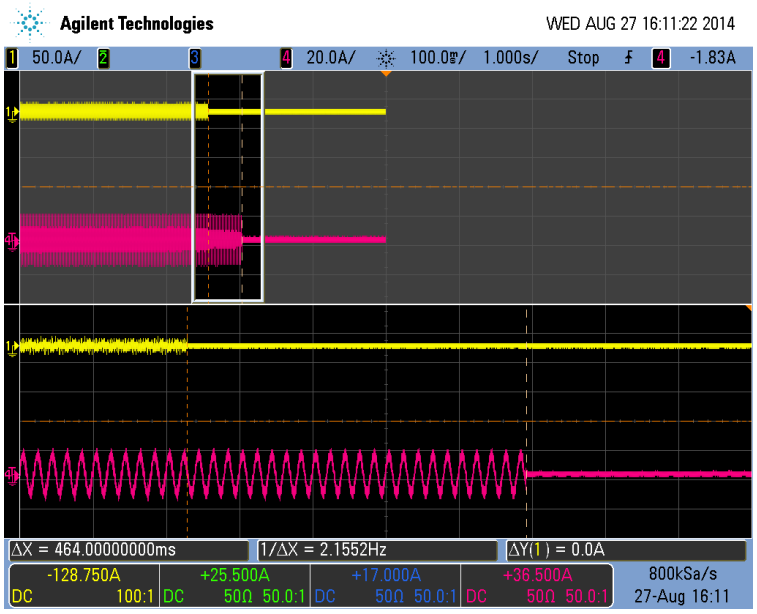
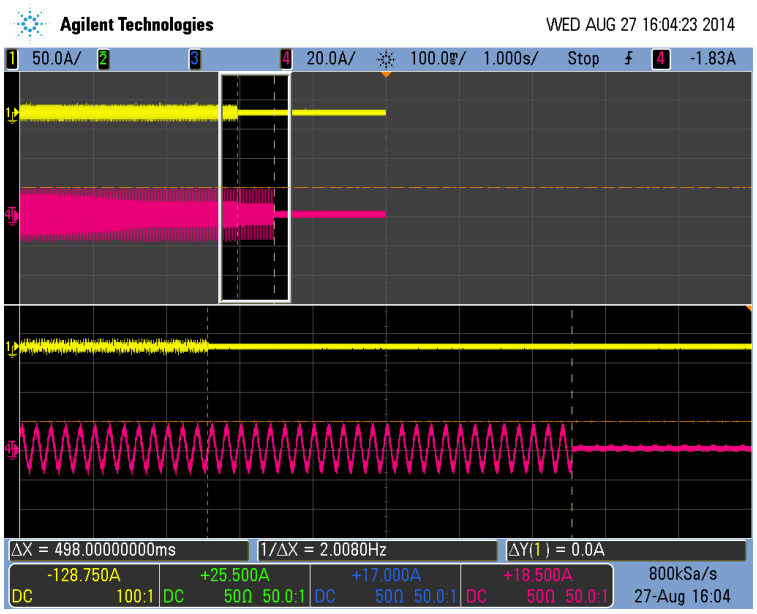
Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 5%	396					
Iteration Phase L3-N	Power output level					
	25%					
Balance condition	P=2090W	Q_L=4530VA	Q_C=4630VA	$P_{Q.WR}$=104VA	Q=2,19	
- 5%	418					

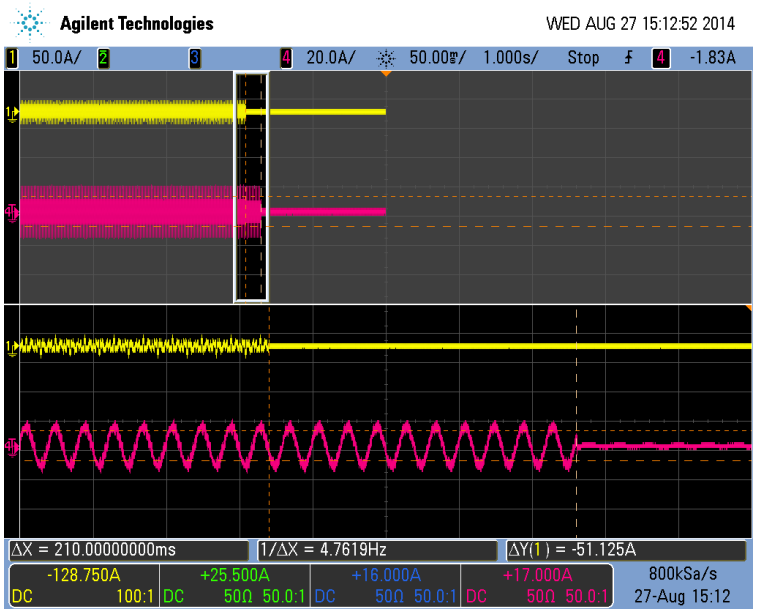
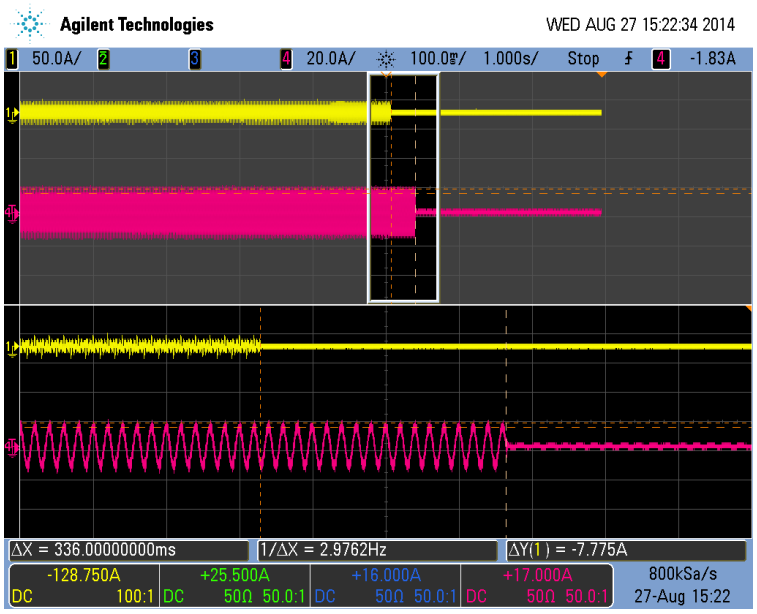
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 4%	516	
- 3%	424	

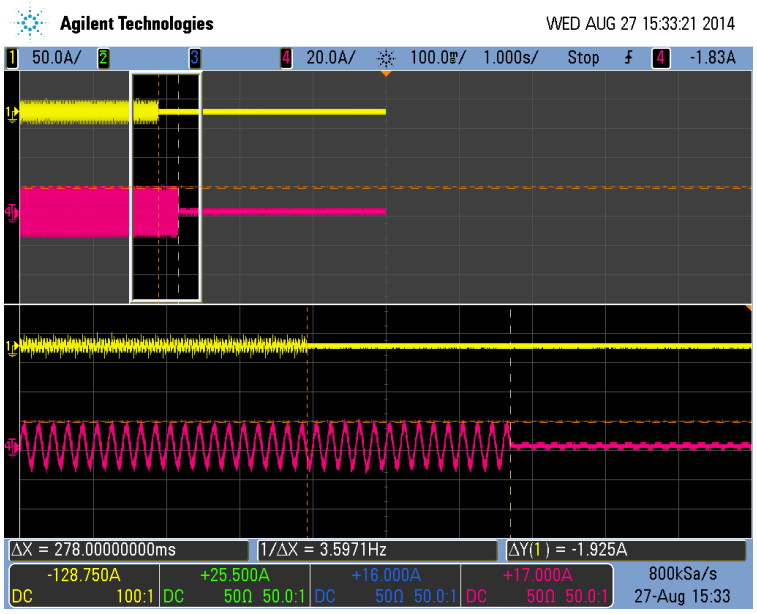
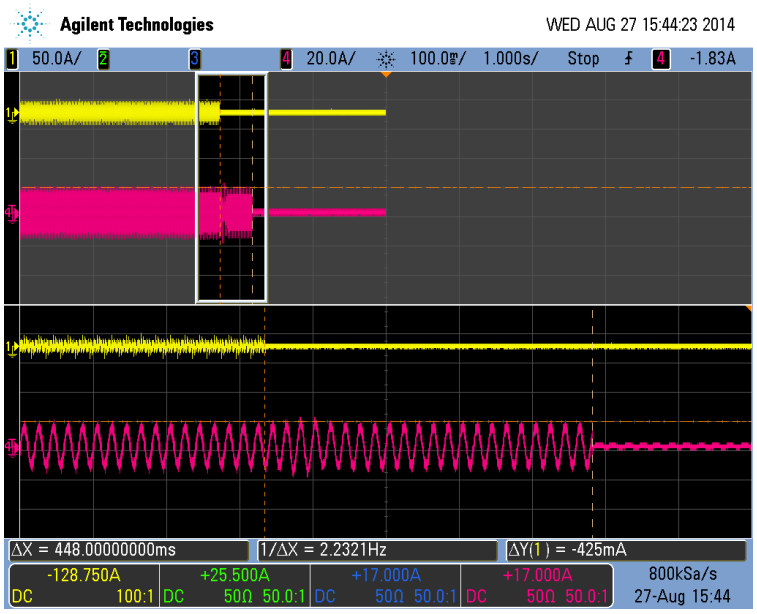
Clause	Requirement – Test	Measuring result – Remark	Verdict

- 2%	464	
- 1%	498	

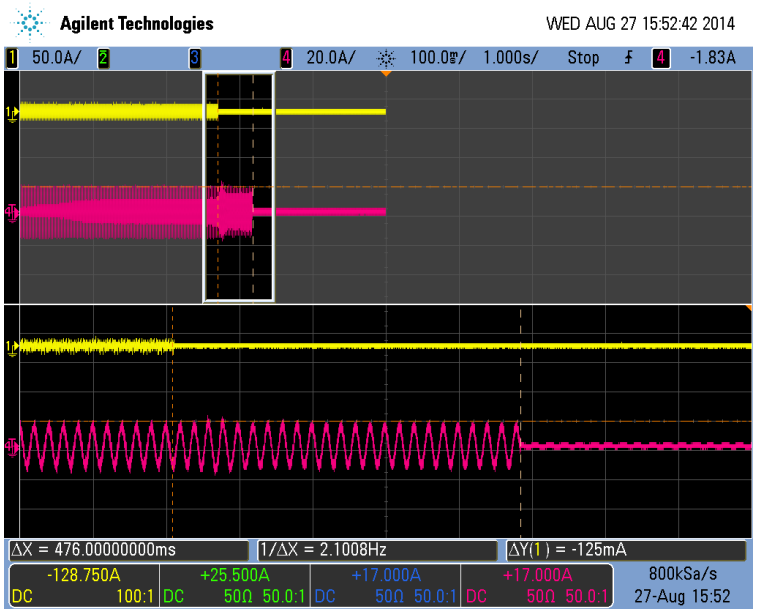
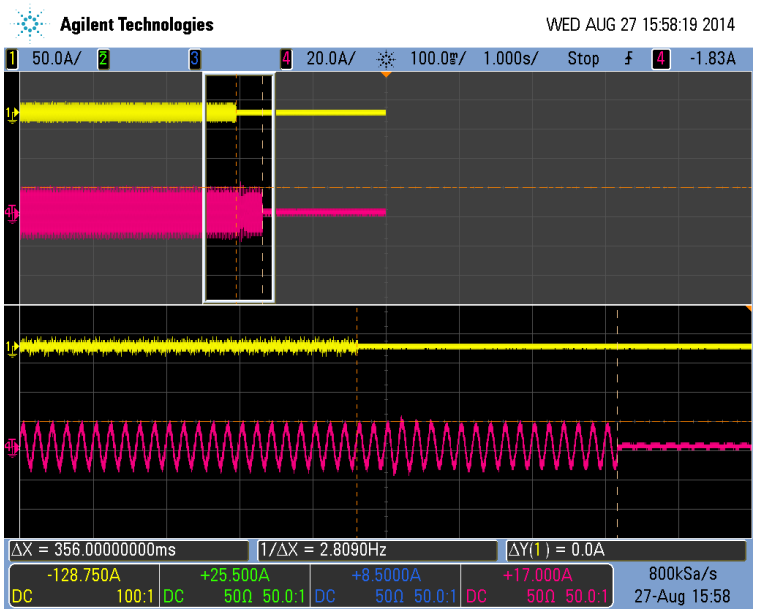
Clause	Requirement – Test	Measuring result – Remark	Verdict

0%	210	
+ 1%	336	

Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 2%	278	
+ 3%	448	

Clause	Requirement – Test	Measuring result – Remark	Verdict

+ 4%	476	
+ 5%	356	

4.8.2 of IEC/EN 62109-2	TABLE: Array insulation resistance detection for inverters for ungrounded and functionally grounded arrays	P
4.8.2.1	Array insulation resistance detection for inverters for ungrounded arrays	

DC Voltage below minimum operating voltage (V)	DC Voltage for inverter begin operation (V)	Resistance between ground and PV input terminal (kΩ)	Required Insulation resistance R = (VMAX PV / 30mA) (kΩ)	Result

Clause	Requirement – Test	Measuring result – Remark	Verdict

ISO setting=100kΩ				
PV+(MPP tracker 1)				
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
PV-(MPP tracker 1)				
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
PV+(MPP tracker 2)				
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
PV-(MPP tracker 2)				
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P
250	300	90	33,3	P

Note:

For isolated inverters, shall indicate a fault in accordance with 13.9 (operation is allowed); the fault indication shall be maintained until the array insulation resistance has recovered to a value higher than the limit above

For non-isolated inverters, or inverters with isolation not complying with the leakage current limits in the minimum inverter isolation requirements in Table 30, shall indicate a fault in accordance with 13.9, and shall not connect to the mains; the inverter may continue to make the measurement, may stop indicating a fault and may connect to the mains if the array insulation resistance has recovered to a value higher than the limit above.

It is not required to test all PV input terminals if analysis of the design indicates that one or more terminals can be expected to have the same result, for example where multiple PV string inputs are in parallel.

Supplementary information:

Additional test with first one pole ground fault, following an insulation resistance below limit simulated, then allow the inverter to start, the inverter shall not connect to the mains. Also tested with blind spot of PV+ and PV- with low insulation resistance together.

Clause	Requirement – Test	Measuring result – Remark	Verdict

4.8.3.5	TABLE: Protection by residual current monitoring	P
Test conditions:	Output power (kVA) : 25 Input voltage (VDC): 640 Frequency (Hz): 50 Output AC Voltage (VAC): 400/230	
4.8.3.5.2	Test for detection of excessive continuous residual current	P

Fault Current (mA)		Disconnection time (ms)	
Measured Fault Current	Limit 300mA for output power ≤ 30 kVA 10mA per kVA for output power > 30 kVA	Measured Disconnection time	Limit
setting: 180mA@240ms + PV1 to N:			
173	300	187	300
178	300	183	300
189	300	185	300
176	300	192	300
172	300	190	300
- PV to N:			
172	300	184	300
171	300	181	300
175	300	175	300
182	300	182	300
176	300	190	300
+ PV2 to N:			
182	300	174	300
181	300	183	300
178	300	185	300
183	300	192	300
176	300	180	300
182	300	174	300

Note:
– maximum 300mA for inverters with continuous output power rating ≤30 kVA;
– maximum 10mA per kVA of rated continuous output power for inverters with continuous output power rating > 30 kVA.

This test shall be repeated 5 times, and for all 5 tests the time to disconnect shall not exceed 0,3s.
The test is repeated for each PV input terminal. It is not required to test all PV input terminals if analysis of the design indicates that one or more terminals can be expected to have the same result, for example where multiple PV string inputs are in parallel.

Supplementary information:

+PV1 and +PV2 used common –PV.

Clause	Requirement – Test	Measuring result – Remark	Verdict

4.8.3.5.3	TABLE: Test for detection of sudden changes in residual current	P
+PV1 to N		
Limit (mA)	UN Disconnection time (ms)	Limit (ms)
Setting: 24mA@120ms		
30	93	300
30	138	300
30	115	300
30	124	300
30	130	300
Setting: 48mA@80ms		
60	123	150
60	101	150
60	89	150
60	102	150
60	69	150
Setting: 100mA@20ms		
150	12	40
150	12	40
150	11	40
150	10	40
150	15	40
-PV to N		
Limit (mA)	UN Disconnection time (ms)	Limit (ms)
Setting: 24mA@120ms		
30	105	300
30	104	300
30	127	300
30	98	300
30	101	300
Setting: 48mA@80ms		
60	89	150
60	71	150
60	99	150
60	66	150
60	91	150
Setting: 100mA@20ms		
150	11	40
150	12	40
150	17	40
150	12	40
150	12	40
+PV2 to N		
Limit (mA)	UN Disconnection time (ms)	Limit (ms)
Setting: 24mA@120ms		

Clause	Requirement – Test	Measuring result – Remark	Verdict
30	96		300
30	126		300
30	101		300
30	115		300
30	129		300
Setting: 48mA@80ms			
60	79		150
60	91		150
60	80		150
60	91		150
60	71		150
Setting: 100mA@20ms			
150	11		40
150	11		40
150	15		40
150	11		40
150	10		40
Note: The capacitive current is risen until disconnection. Test condition: Ic + 30/60/150mA <= Icmax. R1 is set that 30/60/150mA Flow and switch S is closed.			
Supplementary information: +PV1 and +PV2 used common –PV.			